TECHNICAL REPORT:
PHASE II

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MEASUREMENT OF UNIT EFFECTIVENESS IN MARINE CORPS INFANTRY BATTALIONS

Cybernetics Technology Office
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

CACI, Inc.-Federal
Policy Sciences Division

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OCTOBER 31, 1978

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PREFACE

This project was carried out under the sponsorship of the Cybernetics Technology Office of the Defense Advanced Research Projects Agency. The program managers from that office, initially Lt. Col. Roy Gulick (USMC), and, following his retirement, Dr. Stephen J. Andriole, contributed insight, guidance, and bureaucratic support in a helpful, timely, and effective manner.

The project was monitored by the Readiness Branch, Operations Division of Headquarters, United States Marine Corps. Col. Richard J. Johnson, the Contracting Officer's Technical Representative for all except the final few months of the research period, performed admirably in his role. He contributed intellectually to the effort both by raising issues in a timely fashion, and by prompt, thorough, and penetrating criticisms of drafts. He found the time in his otherwise busy schedule to act as an effective liaison for the project with the large number of interested officers and commands whose cooperation and understanding were essential in the effort. Col. Charles H. Knowles, who monitored the last few months of the contract, did so with interest and professionalism. His assistance is also greatly appreciated.

The research would have been nearly impossible if it had not been for the excellent professional assistance provided by the Marine Corps Historical Center. Brigadier General E. H. Simmons, Director of the Center, ensured that the fine research facilities there were fully available to the study team (even permitting access before the building was open to the public), and provided valuable insights and comments on the Phase I research report. Mr. Henry I. (Bud) Shaw helped the research team immeasurably by generously sharing his valuable firsthand familiarity with the historical materials. Ms. Bonnet, the Archives Secretary,

was also generous with her time and demonstrated great professionalism in locating relevant material in the vast and complex storage system. Individual scholars and researchers, pursuing their own projects in the archives, also provided valuable guidance and time saving bibliographic assistance to the research team. The spirit of scholarship present in the Center is truly impressive.

A special word of thanks is due to the 82 officers who invested time and energy to ensure high quality judgmental data in the research effort. They ranged in age and experience from lieutenants to retired lieutenant generals, but all participated gladly and gave professional attention to the tasks asked of them. A research effort is only as good as the information base on which it is constructed. This is particularly true when judgmental information is to be empirically aggregated. Contribution to this effort required long hours of work and deep concentration. These were provided cheerfully, and a number of valuable insights and suggestions were provided by officers who became involved in the study as judgmental coders. Their help is gratefully acknowledged.

Because of the complexity of the research tasks, the cooperation of a variety of military activities and installations was necessary if the project was to succeed. Cooperation from all the organizations and activities was exceptional and the number of individuals who went out of their way to help the research team learn more, gain greater access, and feel welcome was truly impressive.

A visit by the principal investigator to the base at Twenty-Nine Palms, California, provided valuable insight into the live fire exercises conducted there, as well as tactical concepts and procedures for evaluation. Personnel at the Marine Corps Air-Ground Combat Training Center (MCAGCTC) were most helpful and most skillful in explaining, clearly and in detail, the rationale and procedures utilized there.

Observation of a battalion exercise in preparation for deployment to the Mediterranean took the principal investigator to Camp Lejune, North Carolina, by way of the USS Iwo Jima from Norfolk, Virginia. U.S. Navy and Marine Corps personnel preparing for this important exercise were generous with their time in explaining the operation and the use of the Marine Corps Combat Readiness Evaluation System (MCCRES) in the field. Brigadier General McLernan, of the 2nd Marine Division, proved a most helpful host at Camp Lejune. Sessions with Major General E. J. Megarr, Deputy Chief of Staff for Operations and Training, provided further insight into the field exercise and the needs of the Marine Corps.

Officers participating in the coding effort came from a variety of sources, including a number of individual volunteers. However, visits were made to the Army War College, Naval War College (twice), the Education Center at Marine Corps Development Center (MCDEC), and the Amphibious Warfare School at Quantico, Virginia, where officers were available to work on the project. Cooperation at these institutions was exceptional and the research team was able to see new doctrine and tools such as the Tactical Warfare Simulation Analyses System, learn about the curriculum at each institute, and trade ideas and insights with faculty members.

Special thanks are due to Major General E. J. Megarr. His interest in serious research focused on real problems led him to provide special help such as formally inviting retired general officers in the Washington, D.C. area to participate in the program when it was needed.

The research team can only hope that the project to date has proven worthy of the extent and quality of assistance so cheerfully and professionally provided.

The principal investigator for the project is Dr. Richard E. Hayes, manager of CACI's Policy Sciences Division, who is also the principal author of this volume. The historical research and collection of judgmental

data were organized and directed by Maj Gen John J. Hayes, USA(Ret), whose military experience also contributed greatly to the project. Historical work was also undertaken by Dr. Paul Davis, COL, USA(Ret), and Messrs. William Harvey and Gary Keynon. Drs. Bertram I. Spector and David M. McCormick contributed heavily to the original questionnaire design and Mr. Harvey to their redesign for Phase II research. Mr. William Harvey took major responsibility for assembling the Phase I data set, and Dr. Farid Abolfathi executed most of the detailed, multivariate analyses. For Phase II, Dr. David McCormick initially structured the data, and analyses were carried out by Messrs. William Harvey and Steve Harvey. William Harvey performed the analyses of units over time and contributed insightful work in other sections.

The difficult and massive task of producing this report was handled with great skill by the Policy Sciences Division support staff, led by Ms. Kathy Harris. Text typing was largely handled by Karen Wolfe and tables by Briana Taravella. Mara Strock and Lisa Dueno cheerfully provided help whenever it was needed. Mr. James Schlotter did the technical editing under great time pressure.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

LIST OF TABLES

Page

CHAPTER 1

CHAPTER 2

Page

CHAPTER 3

CHAPTER 4

CHAPTER 5

LIST OF TABLES (Cont'd)

LIST OF FIGURES

Page

CHAPTER 1

CHAPTER 2

CHAPTER 12

CHAPTER 15

CHAPTER 16

CHAPTER 1. EXECUTIVE SUMMARY

OBJECTIVES

Combat effectiveness -- the ability of a military organization to achieve its objectives in a hostile environment -- is one of the most important, and yet elusive concepts in the field of military science. This research project focuses on selected aspects of combat effectiveness.

- Its measurement in a reliable, valid way.
- Collection of historical data about factors that might be associated with it.
- Collection of judgmental data from experienced officers about factors they believe are associated with it.
- Analysis of combat effective performance in specific situations:
  - Where units experience severe shock and surprise,
  - In the 1973 Middle East War, and
  - As a single unit changes over time.
- Measurement of field exercise performance in order to determine the likelihood a unit will be combat effective.

Overall, the goal of the project is to determine the correlates of combat effectiveness in order that:

- Units can be designed, equipped, and deployed at the best possible level of readiness,
- Unit training can be focused on those elements that are most likely to improve the probability of combat effective performance, and
- The implications of shifts in resource allocation can be related to the probability of combat effectiveness.

RESEARCH FOCUS AND SCOPE

The primary research focus is on 41 engagements involving U.S. Marine Corps infantry battalions with predominantly offensive missions. Four types of information were developed about each engagement:

1. Historical information on over 200 variables ranging from unit composition to the role of ammunition supply in determining the engagement outcome, and including measures of the combat environment (weather, political constraints, and so forth).

2. Judgmental measures of the combat effectiveness of the unit based on opinions of between 7 and 12 officers who had read a narrative description of the engagement.

3. Judgmental information on the role of 59 critical factors that might have influenced the unit's performance ranging from morale before the engagement to the role of close air support and the weather.

4. Biographic information on the 82 officers who participated in the research.

The engagements were drawn from World War II (15), Korea (12), Vietnam (12), and "Special Operations" (Dominican Republic and Lebanon Landing, 1958) that required tight unit control. The officers participating ranged from lieutenants to retired lieutenant-generals and were drawn from both the U.S. Army and the U.S. Marine Corps. Combat experience by the officer participants ranged from World War II to Vietnam, and some noncombat veterans were included to provide a check on the influence of experience. The bulk of the coders were U.S. Marine Corps combat veterans from Vietnam.

Specific analyses were also carried out to determine:

- What happens to unit effectiveness over time in a hostile environment.

- How units subjected to severe shock and surprise react, and how the correlates of combat effectiveness change under conditions of shock and surprise.

- How the 1973 Middle East War experience differs from the 41 main engagements studied.

- How field exercises and their evaluation can be changed to create units more likely to be combat effective.

MAJOR SUBSTANTIVE FINDINGS

The bulk of the research is reported in terms of coherent sets of variables -- from unit composition and training through the combat environment -- and their association with combat effectiveness measures. The findings for each of these individual types of variables were then integrated into two different views of the battlefield -- the view obtained from historical records and the view obtained from judgmental information provided by experienced officers. These two proved quite different.

- Historical variables highlight the importance of supporting fires, political environment, and other elements outside the battalion, while

- Judgmental variables highlight the importance of command functions (such as adaptive behavior and leadership), planning, intelligence, tactical execution, unit cohesion, and other factors largely contained within the unit.

Integrated View of the Correlates of Combat Effectiveness

Integration of the findings from historical and judgmental research produced the list of factors and approximate weights shown in Table 1. These findings are highly aggregated and represent the results of dozens of specific analyses, comparisons, and research decisions. Much more detailed information is available and discussed in the main body of the report. However, it seems fair to conclude that the research shows that:

- Command activities are the most important correlates of combat effectiveness.

TABLE 1

Factors Influencing Combat Effectiveness

A. Functions

Rank	Factor	Approximate Weight
1	Command - adaptive behavior	.20
2	Command - leadership	.16
3	Creation of local superiority Movement Fire Supporting fires	.15
4	Intense, extended preparatory fires	.13
5	Planning, detailed use of assets	.12
6	Tactical execution	.09
7	Unit cohesion	.08
8	Intelligence	.07
9	Communications	.06
10	Logistics Availability Minimum "Tail"	.05

B. Conditions

Rank	Factor	Approximate Weight
1	Popular support for war	.10
2	Unlimited troop commitment	.07
3	Modern technology battlefield	.05

- Adaptive behavior -- grasping the situation on the battlefield, learning from new information, and altering behavior -- is the most important single activity that a unit can execute.

- Leadership at all levels is essential if combat effectiveness is to be achieved.

- The creation of local superiority through the use of the full arsenal of available tools must be the goal of battalions in combat, making fire coordination a crucial activity. This was most effectively done through the use of:

  - Maneuver,
  - Friendly armor presence,
  - Effective naval gunfire, when available,
  - Artillery fire, and
  - Close air support, when available.

- Preparatory fires can be important, but only if they are extensive (exceed 24 hours), and not in the most difficult of combat situations.

- Planning activities are important elements in determining combat effectiveness.

- Tactical execution, particularly secure movement, choice of positions, and preparation of positions are important elements in determining combat effectiveness (but only about half as important as command activities).

- Political and policy issues well beyond the control of the battalion are associated with combat effectiveness.

  - Popular support for the conflict, and
  - Duration of troop commitment and length of overseas tour.

- Unit cohesion, measured by morale before the engagement, discipline during the engagement, and aggressiveness has a significant influence on the probability of combat effectiveness.

- Intelligence activities, which are intertwined tightly with planning activities and measured principally in terms of awareness of enemy capabilities, are a factor determining combat effectiveness.

- Communication is essential to combat effectiveness and plays its primary role in linking the unit to fire assets -- artillery, close air support, naval gunfire, and armor.

- The local logistics situation influences the probability of combat effectiveness and is composed both of providing vital supplies (especially ammunition) while <u>avoiding</u> provision of large quantities of less vital material that appear to damage combat effectiveness.

- In the engagements studied, U.S. Marine Corps infantry battalions performed best on relatively modern battlefields characterized by enemy artillery concentrations and the presence of enemy armor.

Based on these factors, it was possible to explain about 55 percent of the variation in combat effectiveness in the 41 engagements under study, indicating considerable leverage over effectiveness measures.

The Structure of Combat Activities

Multivariate statistical analyses were applied to the judgmental data in order to determine the structure of battlefield activities as seen by experienced officers. Five major dimensions emerged:

1. A Command function composed of adaptive behavior measures (initiative, resourcefulness, and reaction to the unexpected), personal leadership measures (discipline, aggressiveness, impact of casualties on effectiveness), and tactical leadership measures (planning for the use of subordinate units).

2. A Support and Linkages dimension composed of most of the activities not taking place completely within the battalion itself.

   - External linkages and overall quality of communications.

- Logistics planning and ammunition supply.
- Supporting fires including naval gunfire, artillery, close air support, and armor support.

3. A Planning and Intelligence dimension that inextricably intertwined S-2 functions (quality of information, awareness of the enemy) with S-3 functions (quality of planning, planning for the use of reserves, secure movement).

4. A Tactical Execution function made up primarily of preparation of positions and selection of night positions, but associated with command through maneuver, and with planning through secure movement.

5. A Unit Preparedness/Cohesion function consisting of unit training and morale before the engagement.

Units Over Time

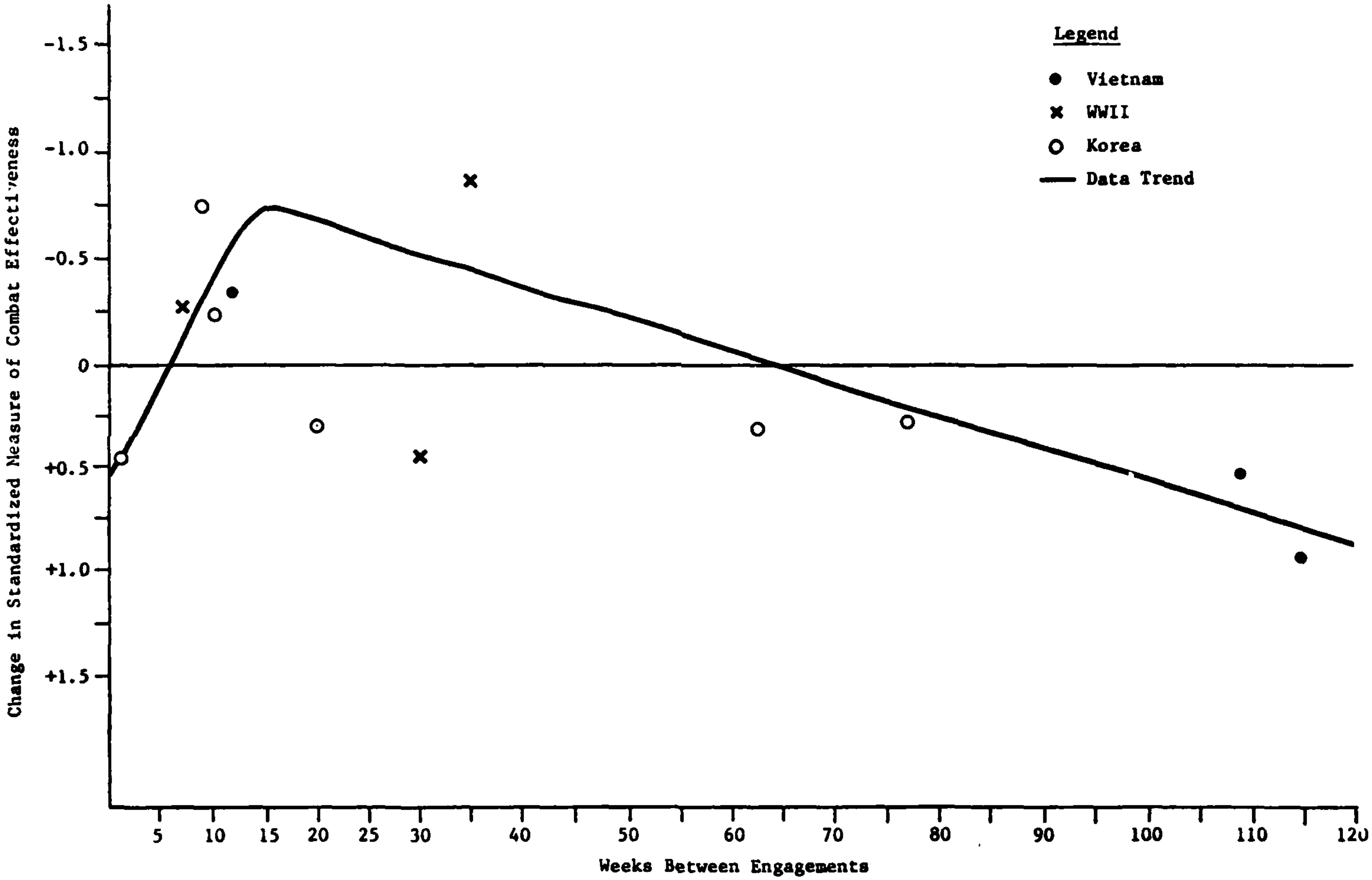
An analysis of the performance of specific units at different points in time to monitor changes in combat effectiveness provided an interesting pattern. Figure 1 shows the result of the analysis. Unit performance can be expected to improve considerably if the gap between engagements is more than 1 week and less than about 4 months. At approximately 4 months, unit effectiveness begins to deteriorate. This deterioration is steady and ultimately results in decreased combat effectiveness.

While the pattern is interesting, the number of data points available is small enough that the finding must be treated with caution. The clarity of the pattern implies that this topic ought to be researched further.

Shock and Surprise

The analyses of units experiencing shock and surprise was one of the more fruitful undertaken. Stated briefly, the conclusions were:

- Surprise by friendly units can increase the probability of combat effectiveness. It is perhaps as important a



Note: Negative Z-score differences mean a positive change in performance (because 1 = best, 10 = worst).

Figure 1. Plot of Standardized Data for Change in Combat Effectiveness

factor as communications and the type and duration of friendly troop commitment.

- The most effective type of friendly surprise is surprising strength rather than tactics, weapons, or location.

- Normal tactical surprise by enemy forces is not associated with lower probability of combat effectiveness by U.S. Marine Corps battalions.

- Under conditions of severe shock and surprise, friendly units must rely on the basic combat functions carried out at the battalion level. The probability of combat effectiveness in these situations depends on actions taken by the unit, not on supporting fires or other outside help.

  - In shock and surprise, local advantage is achieved by maneuver, not by supporting fires.
  - Resourcefulness, discipline, aggressiveness, and reaction to the unexpected are the other key factors correlating with combat effectiveness under severe shock and surprise (see Table 2).

- Unit training is a correlate of combat effectiveness under severe shock and surprise.

- Three of the top 10 correlates of combat effectiveness under conditions of severe shock and surprise are planning functions.

1973 Middle East War Validation

Comparison of the substantive findings from the research with literature and interview data for the 1973 Middle East War was undertaken as a validation effort. While the original research design also called for inclusion of 1973 war cases in the analysis, data availability and timely foreign government cooperation proved to be insurmountable problems.

Remarkable consistency was found between judgmentally defined factors determining combat effectiveness (based on the 1973 war experience and

TABLE 2

Integrated Ranking of Key Variables
in Shock and Surprise Engagements

ID#	Variable	r^2	n	Ranking
C110	Resourcefulness	.22	56	1
C74	Maneuver	.17	63	2
C6	Unit training	.14	55	4
C12	Plan: Quality	.14	64	4
C36	Plan: Use of reserves	.14	55	4
C40	Plan: Subordinate units	.12	51	6
C106	Aggressiveness	.10	62	7.5
C104	Discipline	.10	37	7.5
C100	Reaction to the unexpected	.09	66	9
C92	Position preparation	.09	35	10

Israeli doctrine) and the empirically derived listing (see Table 3). The major "exceptions" were:

- Enhanced need for battlefield intelligence,
- Enhanced salience of threat from enemy artillery, and
- Capability of friendly artillery to stop enemy armor formations with direct fire from prepared positions.

Field Exercises and Their Evaluation

A review of existing field exercises and exercise evaluation systems, carried out both via literature search and personal visits by the principal investigator, resulted in three areas for application of project findings.

1. Alter exercise scenarios to increase the chances that training focuses on functions essential to combat effectiveness:
   - Representation of enemy artillery,
   - Force use of multiple assets and supporting fires to achieve local superiority,
   - Introduce enemy tactical surprise, particularly by novel uses of weapons systems,
   - Provide false battlefield information,
   - Provide stressful scenarios with battlefield restrictions that test unit discipline,
   - Jam communications with higher headquarters to force self-reliance in stressful situations, and
   - Place units on unfamiliar terrain to force adaptive behavior.
2. Utilize the CACI project database to test, revise, and validate both the structure and the weighting system now utilized for the Marine Corps Combat Readiness Evaluation System, and

TABLE 3

Comparison of Israeli Doctrine[a] and Lessons Learned from 1973 Middle East War With Combat Effectiveness Predictors

	Israeli List		Combat Effectiveness Predictors
1	Commander -- undefined	1	Command -- adaptive behavior
2	Command -- structure for adaptive behavior	2	Command -- leadership
3	Command -- leadership	3	Local advantage
4	Local advantage	4	Preparatory fires
5	Troop motivation	5	Planning
6	Reliable fire support (artillery)	6	Popular support
7	Close air support	7	Tactical execution
8	Unit experience relatively unimportant	8	Unit cohesion
		9	Intelligence
		10	Troop commitment
		11	Communications
		12	Logistics
		13	Modern battlefield

[a] Nothing in this discussion relates to official Israeli government doctrine or positions.

3. Collect two new types of behavior during exercises:

   - Adaptive behavior information that measures unit capacity to learn over time, and
   - Unobtrusive physical measures of unit cohesion and motivation on the part of individuals.

TECHNICAL ACCOMPLISHMENTS

In addition to these substantive results, the project has achieved several noteworthy technical objectives.

- The development of one of the largest and most comprehensive data sets in the field of historical combat research. This database has only begun to be exploited and will be an asset in the research area for many years.
- The development, exploration, and validation of a reliable instrument for measuring combat effectiveness. This survey instrument has shown remarkable consistence across officers of different grades, experience, and education. It provides the key ingredient necessary for the systematic analysis of combat effectiveness.
- The development and validation of a sophisticated research methodology capable of blending historical information with judgmental data derived from experienced personnel. This technique has potential for wide application in combat effectiveness and any field requiring consideration of both objective facts and a variety of complex human factors.

FUTURE RESEARCH AND APPLICATIONS

The project team also made six specific recommendations for future applications and continued research work.

- Detailed analyses of the activities of battalion commanders and other key officers in order to better understand:

  - The way they spend their time,
  - The source of characteristics like resourcefulness, initiative, discipline, aggressiveness, and reaction to the unexpected, and
  - How these characteristics can be taught.

- Construction of a simulation model to forecast combat effectiveness based on a knowledge of the unit's attributes, its relative functional capabilities, the support and other resources available to it, and the combat environment (including mission and enemy forces). Sensitivity analyses of the model to develop parameters for influencing unit performance.

- Validation and improvement of MCCRES structures relevant to ground combat.

- Evaluation of environmental variables influencing results of field exercises.

- Review of foreign and historical evaluation systems.

- Application of the research methodology in substantive domains other than infantry battalions, and

- Design of an empirically based budget impact system that can be used to link priority changes and budget shifts to specific changes in the probability of combat effective performance.

CHAPTER 2. METHODOLOGICAL OVERVIEW

INTRODUCTION

The research procedures utilized in this project are sketched graphically in Figure 1. Initial data was acquired by the CACI team from the excellent collection of the United States Marine Corps Historical Branch and Museum. The team identified a set of infantry operations from World War II through Vietnam for which sufficient information existed to produce detailed descriptions of the actions and, at the same time, code a variety of relatively objective historical facts.

CASE SELECTION

During Phase I of the research effort, 22 engagements were selected, 10 from World War II, 5 from the Korean war, 5 from Vietnam, and 2 "special" operations -- the 1958 landings in Lebanon, and the Dominican Republic intervention. For Phase I, which was a pretest of the overall research methodology and approach, only operations involving offensive battalion missions were examined (CACI, 1977). The rationale for this focus was:

- The lowest level of analysis possible was desired in order to ensure focus on combat -- interaction with hostile forces.
- Infantry battalions are the lowest, and therefore most basic, analysis unit for which it is practically possible to collect accurate data.
- Some substantive focus was necessary to produce a coherent data set for analysis.
- Offensive operations are among the most frequent and important undertaken by U.S. military units and are emphasized in current doctrine.

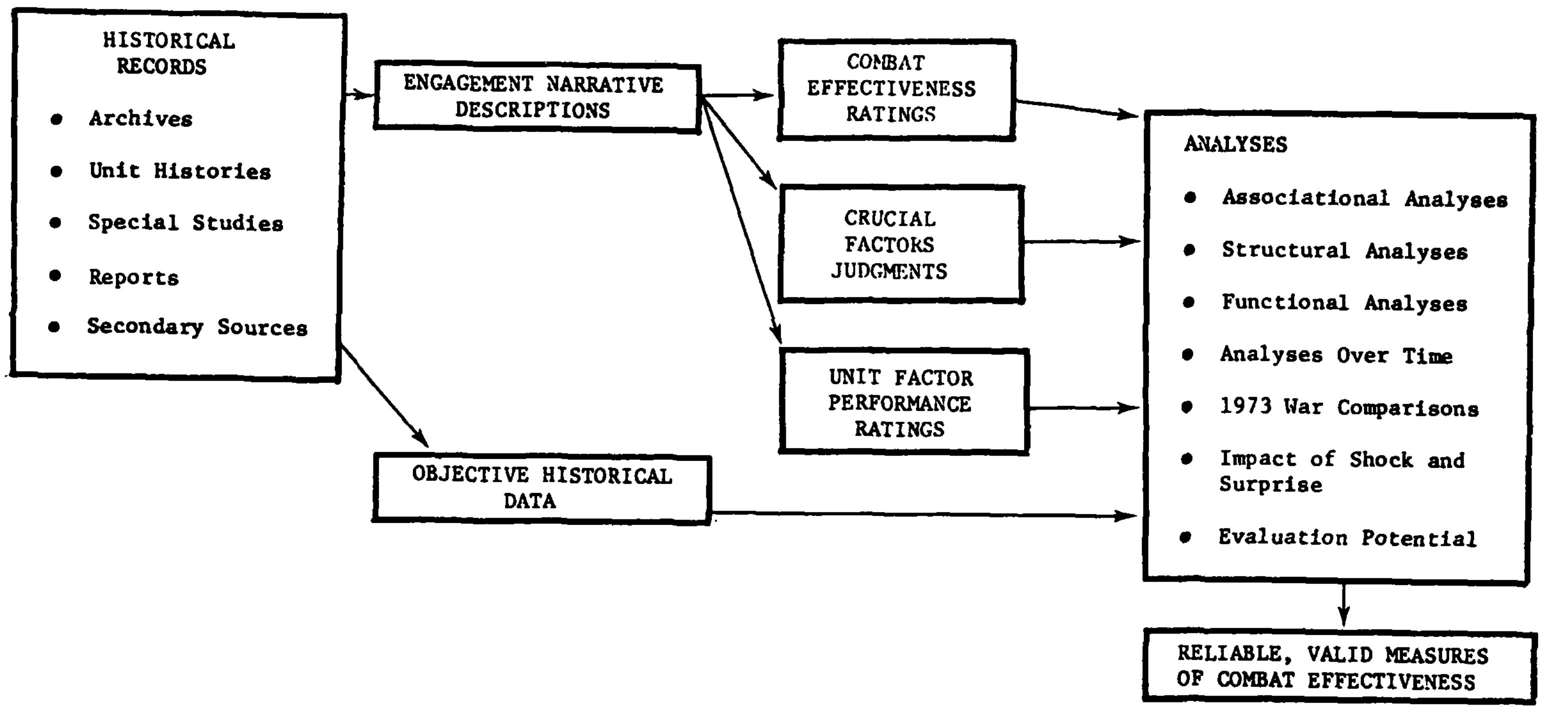


Figure 1. Research Design Overview

U.S. Marine Corps units were selected for three specific reasons:

- The Commandant of the Marine Corps has a strong interest in the subject of combat readiness, as is evidenced by the development of the Marine Corps Combat Readiness Evaluation System (MCCRES) by Marine Corps personnel.
- Headquarters, Marine Corps, provided assistance in the form of an experienced officer to serve as the Contracting Officer's Technical Representative (COTR) for the study.
- Outstanding facilities of the U.S. Marine Corps Historical Branch and Museum were available to support the data collection effort.

The engagements selected for analysis in Phase I research, and later included in the Phase II research effort, are listed in Table 1. Emphasis was placed on World War II because its heavy combat conditions are more like the intensive battlefield expected in the future than those of the other eras. In addition, Vietnam was deliberately downplayed in order to reduce the impact of the most recent combat experience.

The results of Phase I research were promising, and a decision to undertake more extensive research was made. Phase II case selection was, however, based on additional criteria. Cases were specifically sought that would allow:

- Incorporation of other than purely offensive missions.
- Incorporation of cases where shock and surprise were major factors on the battlefield, and
- Incorporation of cases that would reflect the changing effectiveness of battalions over time as they experienced combat, took casualties, and replaced key personnel.

While the focus of cases chosen was broadened somewhat to include operations involving units that were attacking in order to escape precarious

TABLE I

Phase I Cases

ID Number	Combat Era	Unit	Short Title	Reason for Selection
1	WWII	3/1	Peleliu I	Difficult Mission
2	RVN	2/4	STARLITE	Heavy Contact
3	RVN	3/9	DEWEY CANYON	Enemy Antiair
4	WWII	2/1	Peleliu II	Intense Combat
5	RVN	2/5	Hue City	Urban Combat
6	Korea	3/5	Inchon	Hasty Planning
7	RVN	2/3	Khe Sanh I	NVA Opposition
8	RVN	3/3	Khe Sanh II	Intense Combat
9	WWII	2/28	Iwo Jima, Suribachi	Difficult Mission
10	WWII	3/25	Iwo Jima, North	Intense Combat
11	Korea	2/1	Yongdungpo	Urban Anti-mechanized
12	Special	3/6	Dominican Republic	Urban Mission
13	Special	2/2	BLUEBAT (Lebanon)	Exercise Comparison
14	WWII	3/29	Okinawa, Motobu	Difficult Mission
15	WWII	3/29	Okinawa, Oroku	Comparison with Case 14
16	WWII	1/3	Guam I	Difficult Mission
17	WWII	2/9	Guam II	Comparison with Case 16
18	Korea	2/1	Seoul I	Urban Combat
19	WWII	1/29	Saipan	Difficult Mission
20	Korea	3/5	Yudam-ni Breakout	Difficult Mission
21	WWII	2/1	Cape Gloucester	Independent Mission
22	Korea	1/7	JAMESTOWN	Reported Poor Performance

battlefield situations and "sweep" operations in which major contacts occurred unexpectedly, no effort was made to include purely defensive operations or other types of combat so specialized that they might confound the research results.

Cases were selected in which U.S. Marine Corps battalions experienced severe shock and surprise. There were two reasons for this. The research team felt that analysis of the Phase I data had been hampered by a lack of variation in the outcomes -- the units studied had almost all performed reasonably well. In a research project intended to identify the crucial determinants of success and failure it is desirable to have a group of relative failures to compare with outstanding performances. Units experiencing severe shock and surprise were expected to have greater difficulty in achieving their missions, and therefore to provide the desired increased variation.

Second, there are only a few things relatively certain about the battlefield of the future. One of them is that it will not really be what we expect -- particularly what the infantryman expects. Hence, battalions are very likely to experience shock and surprise, particularly in the first crucial days of fighting. An enhanced understanding of the types of units that perform well in shock and surprise situations and the ways they differ from units that perform badly was seen as an important research goal.

Finally, since linking combat effectiveness to combat readiness was a major project goal, it was felt necessary to select cases that would allow tracing of the effects of learning through combat experience. To the extent that the same factors influence combat effectiveness in a single unit over time and in a variety of units chosen at isolated points in time, the research findings can be considered to have enhanced validity. In addition, identification of different critical determinants in veteran units and less experienced units was seen as

a way of improving equipment and training decisions -- allowing development of units more like successful, experienced units through changes in doctrine or emphasis.

The research team originally intended to identify 1973 Arab-Israeli war infantry battalion actions that could be used to validate the findings based on earlier U.S. combat eras and provide insight into a specific type of high intensity battlefield. For a variety of reasons, including the detailed nature of the data needed and the fact that timely foreign government cooperation could not be obtained, the necessary data were not available for this effort.

The cases selected for Phase II research are shown in Table 2. Five additional World War II cases were chosen and seven each from Vietnam and Korea. Eight cases of severe shock and surprise were included. Twelve cases useful in analyses of changes in unit performance over time were also found. These linked backwards to six cases from Phase I. The cases from Phase I and Phase II were merged into a single data set and results reported in this volume reflect analysis of that integrated set.

DATA DEVELOPMENT

A narrative description of each engagement was written by the CACI team based on a combination of historical materials, unit histories, archived records (including original orders and reports), special studies carried out by military analysts and historians, and, where available, secondary sources. Narrative descriptions for engagements 1-22 are presented in the Appendices to Phase I (CACI, 1977). Those for engagements 23-41 are in the Technical Appendix to this report. At the same time, data on the 41 engagements was coded directly by the research team. Codings included:

- Factual data requiring little or no judgment -- the number of personnel in the unit, the length of

TABLE 2

Cases Added in Phase II

ID Number	Combat Era	Unit	Short Title	Reason for Selection
23	WWII	3/9	Bougainville	Unit Over Time
24	WWII	3/9	Guam III	Unit Over Time
25	WWII	3/9	Iwo Jima I	Unit Over Time
26	WWII	2/25	Iwo Jima II	Shock and Surprise
27	WWII	2/2	Tarawa	Shock and Surprise
28	Korea	3/1	Seoul II	Unit Over Time
29	Korea	3/1	Hagaru Perimeter	Unit Over Time
30	Korea	3/1	Hwachon Breakthrough	Unit Over Time
31	Korea	3/1	"BUNKER HILL"	Unit Over Time
32	Korea	1/7	Sudong	Shock and Surprise
33	Korea	2/5	Battle of NW Ridge	Shock and Surprise
34	Korea	3/7	Yudam-ni	Shock and Surprise
35	RVN	2/7	HARVEST MOON	Unit Over Time
36	RVN	2/7	UTAH	Unit Over Time Shock and Surprise
37	RVN	2/7	ALLEN BROOK	Unit Over Time
38	RVN	2/7	MAMELUKE THRUST	Unit Over Time
39	RVN	2/7	IMPERIAL LAKE	Unit Over Time
40	RVN	3/7	TEXAS	Shock and Surprise
41	RVN	1/9	BUFFALO	Shock and Surprise

service of the battalion commander, casualties taken, and so forth.

- Judgments requiring detailed information that could not reasonably be incorporated into the narrative descriptions.

A typical coding sheet for historical data is shown in Figure 2. Two hundred ten historical variables were coded for each of the 41 cases. They range from information on unit composition to details about the enemy situation on the battlefield. The full set of forms is presented in Volume II, the Technical Appendix.

While the historical data were directly usable in analysis, the narrative descriptions formed the basis for generating two types of judgments.

- Ratings of combat effectiveness on the part of the units being studied, and
- Identification of the attributes and activities of the units that experienced officers see as relatively combat effective on the battlefield.

Each of these data generation procedures is described in detail below. Briefly, however, combat effectiveness ratings were elicited from officers with a variety of backgrounds (lieutenant to general officer), different branches (U.S. Army and U.S. Marine Corps), combat veterans from all eras, and nonveterans. They read the narrative descriptions, and rated each unit on mission accomplishment and combat effectiveness. These ratings became the dependent variable -- units rated as performing well were seen as good units and those rated as performing badly were seen as undesirable ones. The research task thus became finding those factors that are present in good units and absent in poor ones.

One way of identifying potential factors that are crucial determinants of combat effectiveness was to ask the same officers to identify activities or functions that the units performed well and those they felt

ENGAGEMENT NO. _____

Operation (Name, location, year) ______________________________

Phase ____________ Dates ______________ to ______________

Unit (Bn, Regt, Div) ______________________________

EQUIPMENT, SUPPLIES, AMMUNITION, AND EVACUATION VARIABLES

1. Equipment Availability:

Type	Not Used (no need) (0)	Not Avail. (should have been) (1)	Reduced (2)	Avail. Essentially as Authorized (3)	Unknown (9)
Landing Craft	___	___	___	___	___
Shore Party Equipment	___	___	___	___	___
Assault Vehicles	___	___	___	___	___
Ground Transport	___	___	___	___	___
Weapons	___	___	___	___	___
Clothing and Equipment	___	___	___	___	___
Communications Equipment	___	___	___	___	___
Other ______	___	___	___	___	___

EQUIPMENT, SUPPLIES, AMMUNITION, AND EVACUATION VARIABLES Form D-9, Page 1 of 3

Figure 2. Typical Historical Data Coding Sheet.

the units did poorly. They were also asked to indicate the importance they felt each factor had in determining the outcome of the engagement (see Figure 3). The officers were provided with forms on which they could rate any of over 60 factors as crucial determinants for any engagement on which they had read the narrative description (the complete form is presented in the Technical Appendix). Of course, results were limited to material discussed in the narrative (although many officers were able to use their experience and judgment to make inferences about the engagement) and to the factors identified on the coding form. The list on the form had been developed and tested during Phase I research. No officer during Phase II suggested any factors be added.

The data generation effort thus produced three data sets:

- A dependent variable -- combat effectiveness ratings-- that was the value to be projected,
- A set of historical observations about the factoral situation on the battlefield, and
- A set of judgmentally defined critical factors believed to be associated with relative combat effectiveness.

ANALYSES PERFORMED

The analysis effort incorporated a variety of techniques and approaches for understanding the relationships among these three data sets. These techniques are explained in layman's terms as they are utilized for the first time in the report. They included:

- Associational analyses,
- Structural analyses,
- Functional analyses,

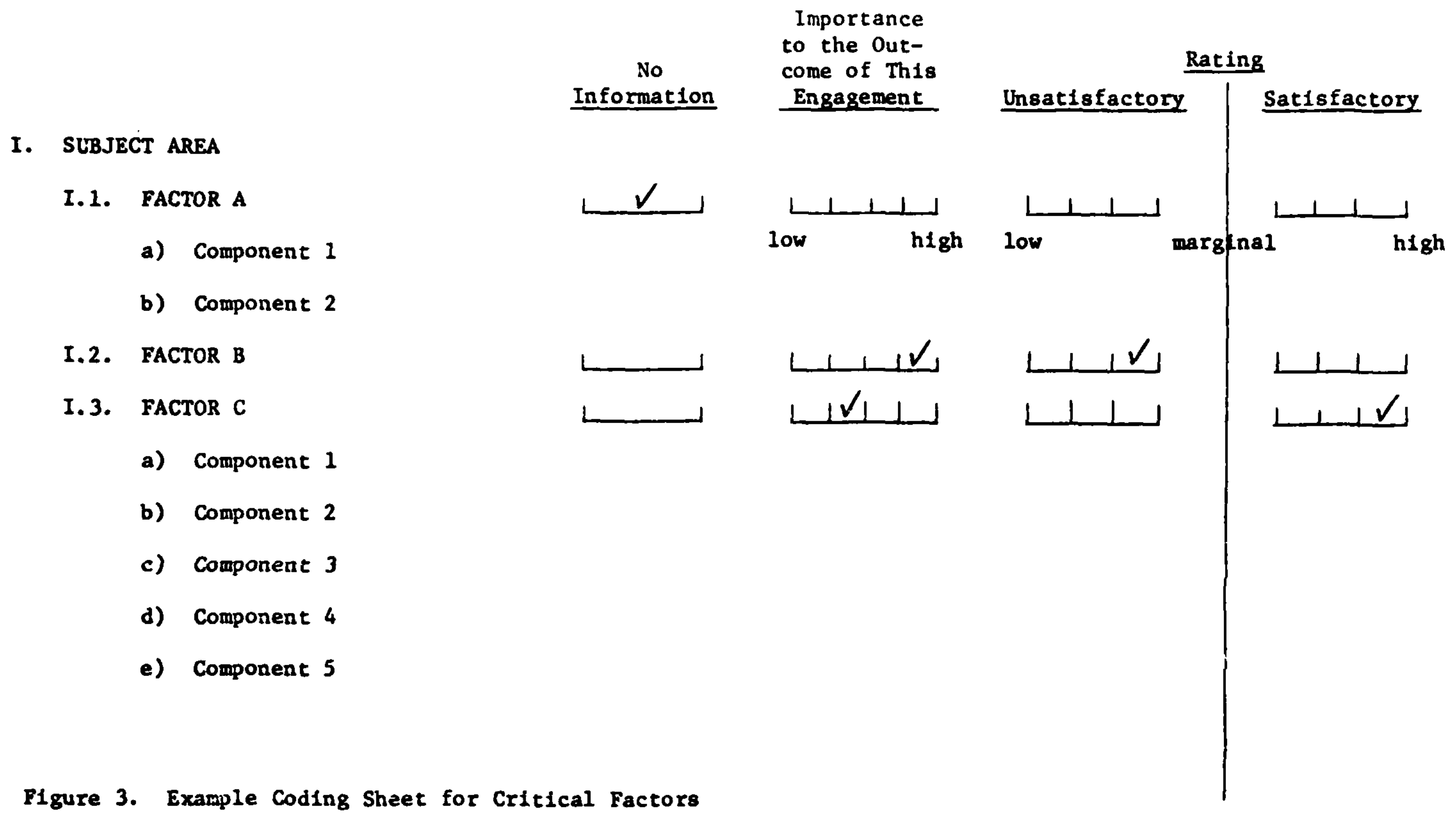


Figure 3. Example Coding Sheet for Critical Factors

- Analyses of units over time,
- Comparisons with the 1973 Israeli experience,
- Analyses of the impact of shock and surprise, and
- Evaluation of the findings for contributions to procedures for evaluation of field exercises and other readiness activities.

The first three types of analyses have different focuses. Associational analyses compare those factors present in cases where combat effectiveness is high with those where it is low. They allow examination of hypotheses about the importance of particular unit attributes or activities. Structural analyses utilize statistical techniques that examine patterns of variables. They tend to be inductive (provide new insights) rather than deductive (test selected hypotheses). Functional analyses utilize preestablished clusters of variables related to generic battlefield activities (fire support) rather than specific systems (field artillery) and help to keep the battlefield in analytical perspective.

Separate analyses, spanning the associational, structural, and functional fields, were performed on subjects of particular emphasis. Hence, analyses of units over time, the 1973 war experience, the impact of shock and surprise, and the implications of this research for evaluation are presented in separate chapters.

MEASURING COMBAT EFFECTIVENESS: THE DEPENDENT VARIABLE

Data Collection

A crucial element in the research was the development of unit performance (relative combat effectiveness) measures. These are <u>not</u> necessarily measures of readiness (levels of preparation), though some measures of readiness may prove to be indicators of combat effectiveness.

It is a basic premise of this study that combat effectiveness is best measured by tapping the judgment of experienced officers on the issue of "mission accomplishment." Regardless of the problems involved, the military functions involved, or the obstacles encountered, units that accomplish their missions are "effective" and those that do not are "ineffective." Military missions are relatively complex and include such components as delaying an enemy advance, seizing specific territory, breaking through a line of resistance, maintaining capability to support other units, and so forth.

The research design called for dealing with this complexity by tapping the experience and judgment of military officers. Active duty and retired U.S. Army and Marine officers in a variety of locations assisted. Eighty-two individual officers participated in data coding. Collectively, they possessed combat experience ranging from World War II through Vietnam. Most were combat veterans, many having had combat command. Volunteers were drawn from among:

- Headquarters, Marine Corps,
- Individuals awaiting assignment to service schools,
- Volunteers from the retired ranks,
- Service School students:
  - U.S. Army War College,
  - U.S. Navy War College,
  - USMC Command and Staff College, Quantico, and
  - USMC Amphibious Warfare School, Quantico.
- Retired Marine Corps general officers, and
- Volunteers who heard about the study.

Each officer was asked to read through a set of narrative descriptions. Upon completing each narrative, the officer filled out a questionnaire entitled "Overall Evaluation of Combat Effectiveness" (see Appendix B

for a copy of the questionnaire). Questions on this form were designed to elicit the officer's judgment of the relative mission accomplishment of the U.S. Marine Corps battalion described in the narrative. A typical question read: Compare the overall combat effectiveness of the friendly battalion with that of units you have seen in combat. Using a 10-point scale, with 10 for the worst performance in the set and 1 for the best performance you have ever personally seen, rank this unit.

Confounding circumstances were also introduced, including terrain, enemy resistance, support received, and the activities of higher headquarters. These factors were included so that statistical checks on the consistency of judgment could be made and sources of uncertainty about rankings identified. The full text of the six versions of the combat effectiveness ranking can be found in the Technical Appendix to this report.

Variable Comparison

The first step was to decide whether the officer coders were using the six different wordings of the combat effectiveness questions:

- Undefined combat effectiveness.
- Combat effectiveness defined as mission accomplishment.
- Combat effectiveness defined as mission accomplishment considering terrain and enemy situation.
- Combat effectiveness defined as mission accomplishment considering the activities of higher command.
- Combat effectiveness defined as mission accomplishment considering support received from outside the unit (artillery, naval gunfire, close air support, armor, and so forth).
- Combat effectiveness defined as mission accomplishment considering all factors mentioned in other questions.

To do this, the rankings provided by all officers for all cases were first correlated, then subjected to a technique called factor analysis. The results of these analyses are presented in Table 3.

Pearson's product-moment correlation coefficients (r) are a measure of the association between data elements. Hence, a high coefficient (approaching +1.00 or -1.00) indicates that values on a specific variable are about the same across cases. Low coefficients (approaching zero) indicate great differences in the values assigned. Positive signs indicate the two variables move up and down together, negative signs indicate a tendency to be mirror images in which a high value on one variable is associated with a low value on the other. Squaring a correlation coefficient provides a new statistic (r^2) that reflects approximately the percentage of the variance in one variable that is associated with the other. Hence, an r of .75 "explains" about 56 percent of variance, .30 about 9 percent.

Table 3A shows the correlation between the answers provided on each of the combat effectiveness rankings. All the correlations are positive and well above .50. There is considerable positive association among the different rankings assigned. The weakest association is between combat effectiveness defined simply as mission accomplishment and considering enemy situation and terrain. There is a variable (effectiveness in light of all factors) that associates strongly with all five of the others. It is a potential "marker variable" that might be used as the best single indicator of combat effectiveness.

Prior to making such a decision, however, the research team subjected the data to another technique -- factor analysis. The key methodological issue related to this data set is whether or not it will form the basis for a coherent scale of combat effectiveness. A good scale is reliable in that a variety of similar efforts will produce similar measures. A variety of techniques can be applied to determine coherence of a data

TABLE 3

Judgmental Measures of Combat Effectiveness

A. Correlation of Alternative Measures of Combat Effectiveness

	A	B	C	D	E	F
A. Undefined Combat Effectiveness	1.00					
B. Mission Accomplishment	.79	1.00				
C. In Light of Enemy and Terrain	.64	.57	1.00			
D. In Light of Higher Command	.69	.62	.63	1.00		
E. In Light of Support Received	.72	.63	.63	.69	1.00	
F. In Light of all Factors	.85	.76	.70	.79	.80	1.00

B. Results of Varimax Orthogonal Factor Analysis

	Factor 1	Communality
A. Undefined Combat Effectiveness	.89	.80
B. Mission Accomplishment	.80	.64
C. In Light of Enemy and Terrain	.74	.54
D. In Light of Higher Command	.81	.66
E. In Light of Support Received	.83	.69
F. In Light of all Factors	.96	.92

Eigenvalue = 4.52

Percent of Variance = 75.4

set. One of the most powerful is factor analysis. Basically, factor analysis is a technique developed to locate clusters of variables that have similar scores. Some scholars think of it as an effort to locate redundancy. It is often employed where a large number of similar variables are being examined. In this context, the technique will demonstrate that there is a set of variables so similar that any one of them can be used as a surrogate or "marker variable" for the set. This allows "data reduction" or simplification of an analytical problem by permitting the analyst to work with a smaller set of variables while ensuring that vital information has not been lost through the elimination of variables.

Factor analysis produces "factors" that are vectors, or paths, through the clusters in the multidimensional data set. It is vital to understand that factor analysis is quite capable of disaggregating a highly related data set into several components. The researcher, by setting the limits for the amount of redundancy or "communality" that is considered in defining a cluster, has some control over the level of discrimination, but there are accepted "default values" for these controls in different disciplines. The technique is also completely statistical -- it will detect theoretically nonsensical clusters as readily as meaningful ones. It is used to explore the "dimensionality" of a data set -- to measure its coherence and to locate its components. Frequently researchers have great difficulty in "naming" factors because they appear to be composed of items that correlate spuriously but do not form meaningful concepts.

The results of a factor analysis for the set of six different measures is shown in Table 3B. Only a single factor, or cluster, was located. It eigenvalue (4.52) is strong (usually any factor with an eigenvalue over 1.00 is considered worthy of attention).

Two types of information are given for the relationship between the scores from each question and the factor or vector that traces their redundancy.

The factor loading indicates the extent to which the variable scores are associated with the values of the factor. The estimated communality focuses on the extent to which the variable participates in the redundancy being examined. These numbers are theoretically bounded between 0 and 1.00. Typically, a loading or communality of 0.30 or higher is seen as signaling a meaningful relationship between a variable and a factor. The values for this factor are very high.

Factor I clearly finds the data on combat effectiveness to be extremely coherent. Over one-half of the variance in every question is associated with the vector (loading greater than 0.71), and all variables participate heavily in the communality. Hence, the first research finding validates a finding suggested by the Phase I research effort.

- Judgmental measures of combat effectiveness form a coherent, unidimensional scale for the 41 engagements examined.

Marker Variable

Once a theoretically meaningful and statistically sound factor has been identified, there are two ways of proceeding. It is possible to generate "factor scores" for each case in the analysis. If these are determined, a new variable is created -- called Factor X -- representing the cluster of variables being examined. The problem with this procedure is that Factor X is neither replicable nor directly interpretable. It is not replicable because the addition of virtually any new data into the set will produce a different solution to the factor analysis, and hence new factor scores for all cases. It is not directly interpretable because it is a statistical artifact composed of positions of observations of reality, and not an observation of reality in itself. The alternative, selection of a marker variable, was chosen to allow for later expansion of the data set and to preserve direct capability to interpret results.

Returning briefly to Table 3B, it is clear that Question F, a 10-point ranking of combat effectiveness, is an excellent marker variable. It has the highest factor loading and highest estimated communality.

Examining the pattern of responses across the six variables, it appears that the first question, undefined combat effectiveness, produces relatively consistent rankings from the officers. As more and more factors are defined and considered, the officer coders reexamine their thinking, show mild disagreement about the outside factors influencing the engagements, but ultimately achieve a high level of consensus about the performance of the battalion under study.

This ultimate consensus reflects the combined military judgment of a number of officers with a variety of backgrounds. Given that an objective of the research project was to develop an instrument for reliably measuring combat effectiveness, this consensus was desirable. Hence, question F and the responses to it were selected as the marker variable to be used throughout the analysis.

Checking for Bias in the Combat Effectiveness Measure

Because the research goals include developing algorithms (procedures) for projecting combat effectiveness, it is important to check the values for possible sources of bias. Table 4, for example, provides the data resulting from a check of the combat effectiveness codings of officers with different types of combat experience. The research procedures utilized here involve:

- Dividing the codings into sets reflecting those coded by individuals with different backgrounds.
- Calculation and comparisons of the means and variances of the two sets of codings.
  - Means reflect central tendency. Since the cases were assigned to the officers randomly,

TABLE 4

Comparison of Outcome Codings Across
Combat Effectiveness

A. Most Recent Combat Experience

Coders	Means	F Probability	T Probability
WWII -- Korea	2.50 -- 3.00	.894	.591
WWII -- Vietnam	2.50 -- 2.92	.613	.741
WWII -- Special	2.50 -- 4.14	.549	.299
Korea -- Vietnam	3.00 -- 2.92	.530	.937
Korea -- Special	3.00 -- 4.14	.444	.375
Vietnam -- Special	2.92 -- 4.14	.615	.074

B. Most Recent Combat Command

WWII -- Korea	2.50 -- 2.56	.883	.882
WWII -- Vietnam	2.50 -- 3.02	.001	.078
Korea -- Vietnam	2.56 -- 3.02	.017	.193

C. Type of Combat Experience

Officer -- Enlisted	3.00 -- 2.62	.042	.135
Officer -- No Combat	3.00 -- 3.01	.473	.930
Enlisted -- No Combat	2.62 -- 3.01	.167	.212
Enlisted -- All Others	2.62 -- 3.00	.053	.122

all subsets will tend toward the same average value unless there is a difference (bias) in the coding by the two groups.

- Variances measure different patterns of dispersion around the means. A difference in the variation can indicate a tendency for greater or less consensus in the codings of different groups.

- Calculation of the F probability and the T probability.

  - The F statistic probability gives the likelihood that the two sets of observations were drawn from populations with the same variance.

  - The T statistic probability gives the likelihood that the two sets of observations were drawn from populations with the same mean.

Generally, probabilities of .05 or smaller indicate a statistically "significant" difference. These probabilities are influenced by both the differences in the key statistics (the relative differences between the two means or two variances) and the number of observations in each set. The more observations, the more likely a *small difference will* be found statistically significant.

Returning to Table 4A, for example, we find the first line of data compares all the cases coded by individuals whose most recent combat experience was in World War II with cases coded by officers whose most recent combat experience was in Korea. World War II veterans coded somewhat more leniently (since rankings were assigned and 1 was the best possible performance, low scores indicate greater lenience). However, the number of cases involved and the size of the difference indicate a .894 probability that the variances come from the same population and a .591 probability that the means come from the same population. Hence, no statistically significant alteration results from mixing the scores of these two groups.

Indeed, the only comparison that approaches significance in the Most Recent Combat Experience group is a comparison of Vietnam veterans with veterans of special operations like the Dominican Republic.

A somewhat different picture emerges when the sets are narrowed to combat commanders and the groups are formed on the basis of most recent combat command (Table 4B). There appears to be some tendency for the Vietnam veteran commanders to give less lenient grades than World War II and Korean veterans. The variances are clearly different, but the means tend in that direction. Since the average scores are not significantly different, it is still possible to combine the values and draw valid conclusions. The variance differences, by themselves, are absorbed when the observations are combined.

A similar situation is observed in 4C where the type of combat experience is compared. Officers whose experience in combat occurred when they were enlisted men have some tendency to give more lenient scores than individuals who have no combat experience or no combat experience as officers. The tendency is not, however, pronounced enough to cause statistically significant difference among the means, though different variances occur. Interestingly, there is no difference between coders who have no combat experience and those whose experience is as an officer.

To check the possibility that the rank of the officer coders would result in different values, the data was broken into four groups -- general officers, full colonels, other field grade officers (almost all lieutenant colonels), and company grade officers.[1] Table 5 shows the results of those analyses. Again, no significantly different means were found although the "other" field grade officers were less lenient than any other group. Interestingly, the most lenient group is the relative inexperienced company

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[1] The inclusion of company grade officers resulted from the cooperation of the Marine Corps Development Center (MCDEC) which arranged to make available some members of a class graduating from the Amphibious Warfare School. Two U.S. Army captains also volunteered to participate.

TABLE 5

Comparison of Outcome Codings Across Combat Effectiveness

Ranks	Means	F Probability	T Probability
General Officer -- Colonel	2.83 -- 2.70	.883	.882
General -- Lt. Col./Major[a]	2.83 -- 3.10	<u>.002</u>	.308
General Officer -- Capt./Lt.	2.83 -- 2.62	.419	.511
Colonel -- Lt. Col./Major	2.70 -- 3.10	<u>.001</u>	.090
Colonel -- Capt./Lt.	2.70 -- 2.62	.750	.757
Lt. Col./Major -- Capt./Lt.	3.10 -- 2.62	<u>.007</u>	.072

[a] The number of majors in the sample was so small as to be insigniificant. They were added in with other Field Grade Officers to reflect their somewhat greater experience.

grade officers, then the general officers, followed by the full colonels. Again, however, none of these differences is significant. Here again, very different variances are seen; but they can be wiped out when the data sets are combined.

The most dramatic effect found in checking for sources of bias appeared when the highest levels of military education of the coding officers were compared (Table 6). Officers whose highest level of military schooling was the U.S. Marine Corps Command and Staff College (the majority of whom coded as they neared completion of the course) tended to code less leniently than any other group (the company grade officers were not included in this analysis). This tendency was so pronounced that a careful review of each of the 41 cases was undertaken to see whether any of them had been coded a disproportionate number of times by this group. Due to the random assignment of engagement to coders, however, no case was coded more than twice by this group. Nevertheless, the difference between these individuals and the rest of the set was large enough and the total number of codings small enough that they were excluded from the analyses. In the chapters that follow all references to the combat effectiveness measure should be assumed to exclude these officers unless explicitly noted otherwise.

Tables 7 and 8 show other checks for bias. The check based on branch of arms shows no significant differences. The lenient rating average for the "other" category (2.17 average ranking) fails to be significant because of the very small number of cases (6) coded by these other branch officers (2). Table 8 shows that no significant differences based on civilian education, and that codings done during Phase I of the research effort are not significantly different from those coded in Phase II. Finally, U.S. Marine Corps Officer coders were compared with U.S. Army coders. While Army officers showed some tendency to code less leniently than USMC officers, the differences do not even approach significance.

TABLE 6

Comparison of Outcome Codings
Across Highest Military Education

School	Means	F Probability	T Probability
USMC CSC -- Army WC	3.87 -- 3.12	.002	.065
USMC CSC -- Navy WC	3.87 -- 2.68	.007	.005
USMC CSC -- AFSC	3.87 -- 2.56	.072	.016
USMC CSC -- NWC	3.87 -- 2.44	.013	.005
Army WC -- Navy WC	3.12 -- 2.68	.798	.088
Army WC -- AFSC	3.12 -- 2.56	.966	.185
Army WC -- NWC	3.12 -- 2.44	.311	.120
Navy WC -- AFSC	2.68 -- 2.56	.853	.779
Navy WC -- NWC	2.68 -- 2.44	.263	.593
AFSC -- NWC	2.56 -- 2.44	.426	.818

USMC CSC = U.S. Marine Corps Command and Staff Course

Army WC = U.S. Army War College

Navy WC = U.S. Navy War College

AFSC = Armed Forces Staff College

NWC = National War College

TABLE 7

Comparison of Outcome
Codings By Branch of Arms

Branch	Means	F Probability	T Probability
Infantry -- Artillery	2.91 -- 3.12	.542	.393
Infantry -- Aviation	2.91 -- 2.86	.171	.904
Infantry -- Others	2.91 -- 2.17	.703	.328
Artillery -- Aviation	3.12 -- 2.86	.327	.522
Artillery -- Others	3.12 -- 2.17	.573	.199
Aviation -- Others	2.86 -- 2.17	.289	.334

TABLE 8

Comparison of Outcome Codings
Across Miscellaneous Variables

Variables	Means	F Probability	T Probability
Civilian Education:			
BA/BS -- MA/MS	3.01 -- 2.83	.151	.392
Phase I -- Phase II	2.75 -- 3.01	.254	.583
USMC -- U.S. Army	2.88 -- 3.13	.506	.261

REVIEWING THE ENGAGEMENT OUTCOMES

Having chosen the measure of effectiveness and determined that coder bias would not be a serious problem in the analysis of the data, the next step was a review of the outcomes by engagement. Table 9 shows the engagements listed from those in which the battalion under study was rated most combat effective though least combat effective. The table shows the ID number of each engagement, its short title, the battalion under study, the combat era, the modal rank assigned by the officer participants, the mean rank assigned, and the number of officers who provided values for the case. Cases were assigned to coders on a random basis so it is not surprising that some were evaluated as many as twelve times while others were evaluated as few as seven.

The performance of the 3rd Battalion, 1st Marines at the Hagaru Perimiter in Korea was the only engagement with a modal rank of 1. The distribution of cases is good with no large gaps between the 1.9 mean ranking for case 30 to the 4.3 for case 32. The larger gaps are where they belong -- near the ends of the range. The mixture of combat eras seems good with all three major eras appearing in the top five and lowest five sets. The two special operations (which did not encounter significant opposition but did require excellent command and control as well as individual discipline) appear near the middle of the data set.

There was a possible bias in the data set toward low scores for the Vietnam War cases. Hence, the cases were divided up by combat era for inspection (Table 10). In addition, tests for differences of means and variances by combat era were also performed (Table 11). The distribution of cases from World War II were narrower (2.0 - 4.0 versus 1.3 - 4.9 for Korea and 2.1 - 5.3 for Vietnam) than for other major combat eras. This apparent difference was confirmed as statistically significant by the F test for differences of variances. The means are not, however, significantly different, so the cases can be examined as a coherent data set.

TABLE 9

Overall Ranking of Engagements

ID Number	Short Title	Unit	Era	Modal Rank	Mean Rank	Number of Coders
29	Hagaru Perimeter	3/1	Korea	1	1.3	9
30	Hwachon Breakout	3/1	Korea	2	1.9	12
10	Iwo Jima, North	3/25	WWII	2	2.0	8
11	Yongdungpo	2/1	Korea	2	2.0	10
38	MAMELUKE THRUST	2/7	RVN	2	2.1	10
26	Iwo Jima II	2/25	WWII	2	2.2	11
5	Hue City	2/5	RVN	2	2.2	9
27	Tarawa	2/2	WWII	2	2.2	9
15	Okinawa, Oroku	3/29	WWII	2	2.3	10
24	Guam III	3/9	WWII	2	2.3	10
33	Northwest Ridge	2/5	Korea	2	2.3	9
20	Yudam-ni Breakout	3/5	Korea	2	2.4	8
19	Saipan	1 29	WWII	2	2.4	7
17	Guam II	2/9	WWII	2	2.4	9
3	DEWEY CANYON	2/4	RVN	2	2.5	8
31	"BUNKER HILL"	3/1	Korea	2	2.5	8
9	Iwo Jima, Suribachi	2/28	WWII	3	2.6	8
12	Dominican Republic	3/6	Special	3	2.6	8
14	Okinawa, Motobu	3/29	WWII	3	2.8	9
6	Inchon	3/5	Korea	3	2.8	10
18	Seoul I	2/1	Korea	3	2.8	10
28	Seoul II	3/1	Korea	3	2.8	10
2	STARLITE	2/4	RVN	3	2.9	9
1	Peleliu I	3/1	WWII	3	3.0	10
25	Iwo Jima I	3/9	WWII	3	3.1	9
13	BLUEBAT (Lebanon)	2/2	Special	3	3.1	8
16	Guam I	1/3	WWII	3	3.1	8
4	Peleliu II	2/1	WWII	3	3.1	7
39	IMPERIAL LAKE	2/7	RVN	3	3.3	11
36	UTAH	2/7	RVN	3	3.3	8
41	BUFFALO	1/9	RVN	3	3.3	12
40	TEXAS	3/7	RVN	3	3.4	11
21	Cape Gloucester	2/1	WWII	3	3.4	9
7	Khe Sanh I	2/3	RVN	4	3.6	10
34	Yudam-ni	3/7	Korea	4	3.7	11
35	HARVEST MOON	2/7	RVN	4	3.8	12
23	Bougainville	3/9	WWII	4	4.0	11
32	Sudong	1/7	Korea	4	4.3	10
22	JAMESTOWN	1/7	Korea	5	4.9	9
37	ALLEN BROOK	2/7	RVN	5	5.1	9
8	Khe Sanh II	3/3	RVN	5	5.3	7

TABLE 10

Ranking of Engagements by Combat Era

World War II

ID	Short Title	Modal Rank	Mean Rank
10	Iwo Jima North	2	2.0
26	Iwo Jima II	2	2.2
27	Tarawa	2	2.2
15	Okinawa, Oroku	2	2.3
24	Guam III	2	2.3
19	Saipan	2	2.4
17	Guam II	2	2.4
9	Iwo Jima, Suribachi	3	2.6
14	Okinawa, Motobu	3	2.8
1	Peleliu I	3	3.0
25	Iwo Jima I	3	3.1
16	Guam I	3	3.1
4	Peleliu II	3	3.1
21	Cape Gloucester	3	3.4
23	Bougainville	4	4.0

Korea

ID	Short Title	Modal Rank	Mean Rank
29	Hagaru Perimeter	1	1.3
30	Hwachon Breakout	2	1.9
11	Yongdungpo	2	2.0
33	Northwest Ridge	2	2.3
20	Yudam-ni Breakout	2	2.4
31	"BUNKER HILL"	2	2.5
6	Inchon	3	2.8
18	Seoul I	3	2.8
28	Seoul II	3	2.8
34	Yudam-ni	4	3.7
32	Sudong	4	4.3
22	JAMESTOWN	5	4.9

Special Operations

ID	Short Title	Modal Rank	Mean Rank
12	Dominican Republic	3	2.6
13	BLUEBAT (Lebanon)	3	3.1

Vietnam

ID	Short Title	Modal Rank	Mean Rank
38	MAMELUKE THRUST	2	2.1
5	Hue City	2	2.2
3	DEWEY CANYON	2	2.5
2	STARLITE	3	2.9
39	IMPERIAL LAKE	3	3.3
36	UTAH	3	3.3
41	BUFFALO	3	3.4
7	Khe Sanh I	4	3.6
35	HARVEST MOON	4	3.8
37	ALLEN BROOK	5	5.1
8	Khe Sanh II	5	5.3

TABLE 11

Comparison of Outcome Codings
Across Combat Eras

Combat Eras Compared	Mean	F Probability	T Probability
WWII -- Korea	2.87 -- 2.75	.012	.631
WWII -- Vietnam	2.87 -- 3.19	.042	.184
WWII -- Special	2.87 -- 3.00	.853	.799
Korea -- Vietnam	2.75 -- 3.19	.583	.119
Korea -- Special	2.75 -- 3.00	.269	.697
Vietnam -- Special	3.19 -- 3.00	.359	.758

THE STRUCTURE OF THE REPORT

The remaining chapters of this volume focus on the research task of identifying predictors of combat effectiveness. First, a series of functional chapters examines the sets of associations present in specific functional areas.

- Unit composition and training (Chapter 3).
- Planning for engagement (Chapter 4).
- Preparatory fires, including air preparations (Chapter 5).
- The actions of the battalion during the engagement (Chapter 6).
- Supporting fires, including armor and air support (Chapter 7).
- Enemy strength and capabilities (Chapter 8).
- Combat support (Chapter 9).
- The combat environment including weather, political constraints and mission type (Chapter 10).

Then, structural analyses are reported in Chapter 11 that integrate and relate these different functional areas to assess their relative contributions and the combinational impact of different functions. This chapter also addresses the problem of writing generalized algorithms for explaining combat effectiveness.

Special analyses of units over time (Chapter 12) and units encountering severe shock and surprise on the battlefield (Chapter 13) are reported in light of the generalized findings. A review of the findings in terms of lessons learned from the 1973 Middle East War (Chapter 14) and the implications of the research for the evaluation of field exercises and preparation of units for deployment in peacetime (Chapter 15) complete the

substantive work. The final chapter deals with future research and application potential for the work.

CHAPTER 3. UNIT COMPOSITION AND TRAINING

INTRODUCTION

The first functional area examined for significant indicators of unit performance is the set of activities and attributes that can be influenced before the unit is committed to combat. Obviously, these are the items that can be most easily affected while the unit remains in a readiness mode. The potential leverage thus established makes these variables extremely important.

The left hand side of Table 1 provides a list of the 29 variables that were deemed worthy of analysis by the research team (a number of others were collected that suffered from insufficient variance or unreliable data coding and were eliminated to ensure the validity and reliability of the results of the project).

JUDGMENTAL VARIABLES

Only two "judgmental" critical factors were available to the officer coders about the unit prior to its deployment. The level of training was coded as significant in 250 officer codings, while morale at the outset of the action was selected somewhat less often (190 officer codings). The mean importance assigned by the officers was 2.7 for training and 2.8 for morale, both very typical of the values assigned to judgmental critical factors. The small "r" reflects the Pearson product-moment correlation between the variable and the dependent variable "combat effectiveness" assigned for the engagement, while "r^2" shows the approximate percentage of the variance in the dependent variable that is associated with the factor. The level of significance, "s", indicates the approximate probability of observing this value of

TABLE 1

Pearson Product-moment Correlation of Combat Effectiveness With Unit Composition and Training Variables

A. Judgmental Critical Factors

ID#	Variable	r	r^2	n	s	Mean Importance
C6	Training	-.35	.12	250	.001	2.7
C8	Morale-Outset	-.24	.06	190	.001	2.8

B. Historical Variables

H8	Bn CO time with unit	-.03
H10	Bn XO time with unit	.07
H12	Bn S-2 time with unit	.06
H14	Bn S-3 time with unit	.22
H16	Bn S-4 time with unit	.06
H18	H&S Co. CO time with unit	-.04
H27	Average time key officers	.07
H30	Officer strength	-.05
H33	Enlisted strength	-.01
H36	Unit strength	.06
H50	Months in theater	.03
H51	Months in combat	.04
H52	Previous operations	.01
H55	Previous similar operations	-.09
H56	Full/Accelerated training	-.07
H57	Bn level training	.02
H58	Regiment level training	.09
H59	Division level training	.02
H60	Field maneuvers	-.07
H61	Rehearsal of operation	.05
H62	Category of friendly troops	.02
H209	Individuals for duration	-.11
H210	Indefinite overseas tour	-.11
H211	Restricted overseas tour	.14
H212	Bn transplant system	-.04
H213	Individual replacement	.04
H214	Mixmaster system	.09

r if the two variables are, in fact, unrelated. Hence, a small s value indicates a "statistically significant" relationship.

From Table 1A, then, it may be inferred that judgmental ratings of training and morale are both significantly related to the combat effectiveness measure. The negative signs are "expected" since combat effectiveness scores are ranked so that 1 is best and 10 is worst, while 6 is the best and 1 is the worst judgmental factors score. Training is associated with about 12 percent of the variance in combat effectiveness and morale with half that much (it is about half as important). As a result, these can be stated as research findings:

- There is a significant relationship between a judgmentally derived measure of unit training and combat effectiveness.
- There is a significant relationship between a judgmentally derived measure of unit morale at the outset of an engagement and combat effectiveness.
- While officer coders believe morale is marginally more important in determining combat effectiveness, the association between their judgments suggests that training is more important, perhaps twice as important.

Historical Variables

Turning to Table 1B, where values for r are shown for a host of historical variables, there is less of interest. None of these values (reflecting the length of service of key personnel, unit strength, unit experience, specific training experiences, or personnel policies) associate significantly with outcomes. Since there are only 41 engagements and not all data are available for all cases, a stronger association is required to achieve significance in these values. Even the promising .22 association between battalion S-3 time and unit combat effectiveness is apparently a statistical artifact, for it is in the wrong direction.

At times, when the number of cases is small, the presence of a relationship will be masked by the use of a single summary statistic such as the r value. Hence, a number of theoretically interesting historical variables were examined in greater detail by the use of a simple calculation statistic -- the chi-square. This technique calls for breaking the data into unit specific groups that reflect patterns in the independent and dependent variables. For example, in Table 2A we see a chi-square analysis based on the length of time the battalion commander had been with the unit prior to each engagement. Three groups were created reflecting differing lengths of service: cases where the battalion commander had been with the unit less than one month, between one and four months, and more than four months. The dependent variable, combat effectiveness, was divided into two groups -- those with mean effectiveness rankings from 1 to 2.79 (21 cases) and those with mean effectiveness rankings of 2.8 and above (20 cases). The cases were then placed in the 3 x 2 matrix created by these variables. An inspection makes obvious that the outcome of a case is very difficult to predict based on knowledge of the amount of time the battalion commander has been with the unit. The chi-square statistic (which can take values larger than 1) is small and the s level indicates a high probability that all three groups come from the same population.

Similar results are found for most of the other variables tried: average time of key officers (including company commanders) with the battalion, months in the theater, number of previous operations, battalion training, division training, field maneuvers, and rehearsal for the operation. A nonsignificant tendency to perform better does appear for units that have completed accelerated training. A stronger, but still nonsignificant, tendency is for units that have not experienced regimental training to perform better than those that have some or extensive training. An extremely interesting finding arises, however, from Table 2K. Two (identical) independent variables -- the length of individual commitments and the indefiniteness of overseas tours -- are associated with combat effectiveness.

TABLE 2

Selected Analyses of Historical Variables Related to Unit Composition and Training

A. Time of Bn Commander With Unit

		0-1 mo.	1-4 mo.	4 mo. +	
Mean Outcome Scores	1-2.79	7	8	6	21 51.2%
	2.80 +	7	6	7	20 48.8%
		14 34.1%	14 34.1%	13 31.7%	41

Chi-square = .38 2 degrees of freedom s = .84

B. Average Time Key Officers With Unit

		0-1 mo.	1-4 mo.	4 mo. +	
Mean Outcome Scores	1-2.79	2	2	2	6
	2.80 +	0	5	3	8
		2	7	5	14

Insufficient data to calculate probabilities, no discernable trend.

C. Months in Theater

		0-6	7-12	13-18	18 +	
Mean Outcome Scores	1-2.79	9	3	4	5	21
	2.80 +	8	4	3	5	20
		17	7	7	10	41

Chi-square = .32 3 degrees of freedom s = .96

D. Previous Operations

		0	1	2	
Mean Outcome Scores	1-2.79	4	11	6	21
	2.80 +	5	10	5	20
		9	22	11	41

Chi-square = .23 2 degrees of freedom s = .89

Continued

Table 2
Historical Variables
Continued

E. Unit Training

		Full	Limited/ Accelerated	
Mean Outcome Scores	1-2.79	9	12	21
	2.80 +	10	8	18
		19	20	39

Chi-square = .22 1 degree of freedom s = .64

F. Battalion Training

		None/ Slight	Extensive	
Mean Outcome Scores	1-2.79	11	9	20
	2.80 +	13	7	20
		24	16	40

Chi-square = .10 1 degree of freedom s = .75

G. Regimental Training

		None	Slight	Extensive	
Mean Outcome Scores	1-2.79	7	7	6	20
	2.80 +	3	10	6	19
		10	17	12	39

Chi-square = 2.1 2 degrees of freedom s = .35

H. Division Training

		None	Some	
Mean Outcome Scores	1-2.79	8	12	20
	2.80 +	5	8	13
		13	20	33

Chi-square = .07 1 degree of freedom s = .78

Continued

Table 2
Historical Variables
Continued

I. Field Maneuvers

		No	Yes	
Mean Outcome Scores	1-2.79	6	15	21
	2.80 +	5	10	15
		11	25	36

Chi-square = .003 1 degree of freedom s = .95

J. Rehearsal

		Yes	No	
Mean Outcome Scores	1-2.79	8	13	21
	2.80 +	6	14	20
		14	27	41

Chi-square = .05 1 degree of freedom s = .83

K. Individuals Committed for the Duration and Indefinite Overseas Tours (identical variables)

		No	Yes	
Mean Outcome Scores	1-2.79	4	17	21
	2.80 +	10	10	20
		14	27	41

Chi-square = 3.1 1 degree of freedom s = .08

These are, of course, variables that have been historically determined by policy makers and associate directly with combat eras. A clear, statistically almost significant relationship is present:

- The probability of superior combat effectiveness is increased when overseas tours are unlimited and individuals are committed for the duration of the conflict.

The other findings are not so dramatic. They include:

- There is no evidence that the period of time key officers have been with the unit influences the probability of combat effective performance.

- There is no evidence that unit strength influences the probability of combat effective performance.

- There is no evidence that previous combat, per se, influences the probability of combat effective performance (this issue is addressed in greater detail, and, with somewhat different results, in Chapter 12).

- There is a statistically nonsignificant tendency for units with accelerated or limited training and units with no regimental training to perform better than other units. Otherwise, there is no evidence that training patterns, including field maneuvers and operations rehearsals, influence the probability of effective combat performance.

These findings corroborate those of the Phase I research effort. Some of the caveats voiced there are apparently still appropriate.

- The number of observations on historical variables remain woefully small.

- The findings regarding limited training probably reflect the tendency to accelerate training for units needed for an ongoing war. These units may train briefly, but they also train intensively and seriously.

- The finding regarding regimental training is associated with the use of regiments during World War II for amphibious landing training. Long periods of these activities apparently distracted attention from more basic unit training.

Discriminant Function Analyses of Judgmental Variables

Having found two apparently good judgmental variables, the research team wanted to have a better idea of their relative importance or predictive power. To gain this, a set of discriminant function analyses were performed. In discriminant function analysis, the key question is how many of a set of cases the predictor (independent) variable will assign correctly to prespecified groups. In this case, the officer codings of senior officers (above captain) were utilized. This provided a pool of 258 codings on the training variable and 190 on the morale variable. The cases were grouped by rank assigned, with rankings of 1-3 (good performance) being group 1 and 4-10 (poor performance) being group 2.

The results of these analyses are shown in Table 3. If all the research team knew about a case was its judgmental assignment of a value on unit performance for training, it could correctly place it in a combat effectiveness group more than two-thirds of the time. Given the morale at the outset of a battle, the correct combat effectiveness groups could be selected slightly better than three out of five times. There remains a difference in the predictive power of the two factors -- training is a better predictor than morale -- but the size of the difference is smaller with this technique than when correlations are used.

Relationships Among Unit Composition and Training Variables

Before leaving this set of variables, it was necessary to examine the relationships among the predictor variables. First, since training and morale are both predictors, it was necessary to find out the extent to which they are associated -- predicting the same part of the variation

TABLE 3

Discriminant Function Analyses of Judgmental Critical Factors as Predictors of Combat Effectiveness

A. Training

		Predicted Group Membership	
		Group 1	Group 2
Group 1 Rank = 1-3	180 69.7%	125 69.4%	55 30.6%
Group 2 Rank = 4-10	78 30.2%	28 35.9%	50 64.1%

Percentage of grouped cases correctly classified = 67.8

B. Morale at Outset

		Predicted Group Membership	
		Group 1	Group 2
Group 1 Rank = 1-3	135 71.1%	76 56.3%	59 43.7%
Group 2 Rank = 4-10	55 28.9%	16 29.1%	39 70.9%

Percentage of grouped cases correctly classified = 60.5

in combat effectiveness. Second, the question of whether there were associations between the judgmental variables and historical variables (which might be used as surrogates for the judgmental variables) also needed to be addressed.

Table 4 shows the correlations between the two judgmental variables and selected historical variables. Judgmental training and judgmental morale show considerable association ($r = .480$, $s = .001$), hence, there is a good chance that they explain the same part of the variance in the independent variable.

Comparing the judgmental variables with the historical factors, however (by measuring association between mean critical factors ratings and historical values), reveals a noteworthy pattern. These associations suggest both the set of historical observables that are reflected in the judgmental ratings assigned by the officer coders and surrogate variables. The length of time the battalion commander has been with the unit, total officer strength, division training, and the use of maneuvers are significantly positively associated with judgmental ratings of good training. Rehearsals are significantly negatively associated. A number of other variables are close to significant relationships.

Morale has fewer associations, with only two personnel rotation policies having significant relationships (in both cases these policies applied in only three engagements and are therefore difficult to generalize). Near significance is achieved by battalion commander and executive officer continuity, however.

Interpretation of this type of finding is complex. Variables having no direct association with combat effectiveness associate indirectly with it through judgmental factors that show predictive power. This condition could result in two ways. On the one hand, the historical variables may reflect the detailed clues that the officer coders were seeing in

TABLE 4

Interesting Correlations Between Independent Variables in the Unit Composition and Training Set

A. Association With Judgmental Training Score

ID#	Variable	r	n	s
C8	Morale at outset	.48	170	.001
H8	Bn CO time with unit	.58	34	.001
H10	Bn XO time with unit	.31	25	.07
H14	Bn S-3 time with unit	-.17	17	.26
H27	Average time key officers	-.28	19	.12
H30	Total officer strength	.34	26	.04
H56	Full/Accelerated Training	-.18	39	.13
H57	Bn level training	.25	41	.06
H58	Regimental training	.26	39	.06
H59	Division training	.40	33	.01
H60	Maneuvers	.39	36	.01
H61	Rehearsal	-.28	41	.04

B. Association With Judgmental Morale at Outset (C8)

H8	Bn CO time with unit	.18	34	.09
H10	Bn XO time with unit	.25	25	.08
H14	Bn S-3 time with unit	-.14	17	.30
H27	Average time key officers	.11	19	.32
H62	Category of friendly troops	-.03	41	.88
H210	Individuals for duration	.02	41	.89
H211	Restricted overseas tour	-.11	41	.15
H212	Bn transplant system	.23	41	.05
H213	Individual replacement	-.17	41	.12
H214	Mixmaster system	.60	41	.001

the narrative descriptions and aggregating with their overall judgments about training and morale. A more likely possibility is that the historical variables contribute to morale and training but were never really seen by the officer coders. Reasonable and hopeful research findings suggested by the data are:

- Informed, experienced officers' judgments are a superior predictor of combat effective performance based on unit composition and training history than individual historical variables about the same units, or more simply, the ability of an informed, experienced human mind to integrate specific information into a sound judgment is superior to making the same judgment on the basis of isolated facts.

- The information appears to be present in the historical data about unit composition and training to develop surrogate measures for them.

CHAPTER 4. PLANNING PHASES

INTRODUCTION

Analysis of the planning phases of an engagement contrasts with that of the unit composition in that there are several judgmental variables available, but only a couple of historical variables. Two of the planning phase variables -- quality of available information and awareness of enemy capabilities -- are primarily intelligence functions. Specific consideration was also given to the use of reserves, subordinate units, timeliness of orders, and logistical planning. Two general variables -- quality of plan and consistency of planning with the principles of war -- were also included. The historical data on planning relates to the level of command with primary planning responsibility, and the nature of the planning process (hasty or deliberate).

JUDGMENTAL VARIABLES

Basic information about the judgmental variables is presented in Table 1. All the variables have significant relationships, in the predicted direction, with the combat effectiveness measure. Several of the percentages of variances (r^2) are, however, quite small. The largest relationship is between combat effectiveness and planning for the use of subordinate units. The two general planning variables also show reasonable relationships. Awareness of enemy capabilities, use of reserves, and timeliness of orders have approximately 10 percent explained variance. Quality of information and planning for use of logistics have weak associations.

The right column shows the mean importance assigned to each variable by the officer coders. Quality of information (empirically not important)

TABLE 1

Pearson Product-moment Correlation of Combat Effectiveness With Planning Phase Variables

A. Judgmental Variables

ID#	Variables	r	r^2	n	s	Mean Importance
C10	Quality of information	-.20	.04	273	.001	2.8
C12	Plan quality	-.36	.13	281	.001	2.7
C14	Plan: Principles of war	-.40	.16	237	.001	2.7
C34	Timeliness of orders	-.32	.10	232	.001	2.5
C36	Plan: Reserves	-.30	.10	236	.001	2.6
C38	Plan: Logistics	-.24	.06	199	.001	2.7
C40	Plan: Subordinate Units	-.47	.22	208	.001	2.8
C42	Awareness of enemy	-.32	.10	264	.001	2.7

B. Historical Variables

ID#	Variables	r
H92	Level of planning	.14
H93	Hasty/Deliberate	.03

ties with use of subordinate units (empirically the strongest). Timeliness of orders, and planning for use of reserves, rated least important by the officer coders, do indeed have relatively weak associations.

HISTORICAL VARIABLES

The two historical variables in the planning phase -- level of the headquarters with primary planning responsibility and the nature of the planning process (hasty versus deliberate) -- associate relatively weakly with the combat effectiveness measure (Table 1B). To ensure valid analyses, the research team examined the cases in greater depth. Table 2A shows the distribution of primary planning responsibility across battalion, regiment, division, and other types of headquarters plotted against the mean effectiveness scores assigned by the officer coders. There appears to be a tendency for regimental level planning to be associated with less combat effectiveness and divisional with greater effectiveness. These tendencies are not so pronounced as to be statistically significant, but they are suggestive. A closer examination shows that the regimental planning data are largely composed of World War II cases while division level planning is a mixture of Korean and World War II situations. Time available for planning shows no clear pattern of association with combat effectiveness rankings (Table 2B).

Two research findings can be stated:

- There are slight, nonsignificant tendencies for operations planned at the regimental level to go poorly and for those planned at the division level to go well.

- The need for hasty or improvised planning shows no significant association with improved or diminished combat effectiveness when compared with deliberately planned operations.

TABLE 2

Association of Historical Variables
Related Planning With Combat Effectiveness

A. Level of Command with Primary Planning Responsibility

		Battalion	Regiment	Division	Other	
Mean Outcome Scores	1-2.79	2	4	13	2	21
	2.80 +	2	7	9	2	20
		4	11	22	4	41

Frequencies are too small to permit meaningful statistical summarization.

B. Time Available for Planning

		Hasty/ Improvised	Deliberate	
Mean Outcome Scores	1-2.79	9	12	21
	2.80 +	7	12	19
		16	24	40

Chi-square = .004 1 degree of freedom s = .95

PRINCIPLES OF WAR

The Phase I research had failed to find significant association between application of the principles of war in the planning phase and the combat effectiveness variables. Having found a statistically significant association in this more general data set, the research team checked to see that the overall variable "consistency of planning with the principles of war" would make a good representative variable for the nine individual principles recognized in Marine Corps doctrine. Table 3 shows the pattern of correlation between the overall principles variable and each individual principle and among the nine principles. No individual principle is poorly represented by the overall measure. Surprise is the least associated with the overall value ($r = .47$), while economy of force is the best represented ($r = .70$). Since surprise was to be treated separately in the chapter on shock and surprise, the decision was made to exclude the individual principles from further analysis in the planning phase data set.

CORRELATIONS BETWEEN JUDGMENTAL VARIABLES

Since the entire set of judgmentally derived planning variables had shown significant association with the combat effectiveness measures, it was necessary to examine their relationships with one another. The key issue was redundancy -- whether some of the variables could safely be ignored because they were associated with the same variance as other variables and could not be distinguished conceptually.

When independent variables are associated with one another at significant levels we are faced with a statistical problem called "multicolinearity". To take a simple example, if an individual loses his job, gets a divorce, and goes on a drunken binge on the same night, it can be argued that he is drinking because of the loss of his job, the divorce, or some combination of or interaction between the two. There is no

TABLE 3

Correlations Between Judgmental
Values on Principles of War

ID#	Variable	C14	C16	C18	C20	C22	C24	C26	C28	C30	C32
C14	Overall Principles	1.00									
16	Objective	.69	1.00								
18	Offensive	.65	.67	1.00							
20	Mass	.68	.49	.62	1.00						
22	Economy of Force	.70	.58	.51	.62	1.00					
24	Maneuver	.68	.62	.63	.62	.63	1.00				
26	Unity of Command	.58	.56	.49	.54	.60	.57	1.00			
28	Security	.59	.46	.45	.53	.55	.54	.57	1.00		
30	Surprise	.47	.44	.36	.45	.51	.47	.47	.55	1.00	
32	Simplicity	.51	.52	.51	.49	.46	.55	.65	.52	.48	1.00

logical or statistical way to sort out the effect of these two factors without more information (for example, he has lost nine previous jobs but never before taken a drink in his life) or a theoretical framework (money is less important than a happy family life) that orders the data for us.

Examining Table 4, the pattern of intercorrelation makes clear that the judgmental planning variables are intercorrelated to a significant degree. The decision was made to eliminate the variable "consistency of planning with the principles of war" because of its high correlation with the general variable "quality of plan" (r = .77) and the vagueness of both concepts. The two intelligence variables, intercorrelated at .61 were also identified as candidates for elimination, but their different percentages of variance explained in the simple correlations (Table 1) argued for temporary retention. No other clear candidates for elimination emerged.

DISCRIMINANT FUNCTION ANALYSES

The next step was a review of the independent predictive power of the seven remaining judgmental planning phase variables by using them as independent variables in a discriminant function analysis. The dependent variable was the individual rankings on combat effectiveness assigned by the officer coders. Two groups were established -- rankings from 1-3 and from 4-10. The results of these analyses are shown in Table 5.

The best single predictor variable was planning for the use of subordinate units (67.3 percent of cases predicted correctly based only on knowledge of this one variable) followed closely by overall plan quality (66.2 percent) and timeliness of orders (65.1 percent). A middle group consisted of logistics planning (62.3 percent) and planning for the use of reserves (60.2 percent). The two intelligence variables performed weakest (no more than 58 percent).

TABLE 4

Correlations Between
Judgmental Planning Variables

ID#	Variable	C10	C12	C14	C34	C36	C38	C40	C42
C10	Quality of information	1.00							
C12	Plan quality	.56	1.00						
C14	Plan: Principles of War	.43	.77	1.00					
C34	Timeliness of Orders	.43	.52	.40	1.00				
C36	Plan: Reserves	.44	.52	.49	.50	1.00			
C38	Plan: Logistics	.40	.42	.37	.44	.40	1.00		
C40	Plan: Subordinate Units	.32	.53	.42	.40	.42	.30	1.00	
C42	Awareness of enemy	.61	.54	.54	.43	.46	.34	.44	1.00

TABLE 5

Discriminant Function Analyses of Judgmental Critical Factors as Predictors of Combat Effectiveness

A. Quality of Information

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	186 68.1%	90 48.4%	96 51.6%
Group 2 Rank 4-10	87 31.8%	25 28.7%	62 71.3%

Percent of grouped cases correctly classified = 55.7

B. Plan Quality

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	193 68.6%	123 63.7%	70 36.3%
Group 2 Rank 4-10	88 31.3%	25 28.4%	63 71.6%

Percentage of grouped cases correctly classified = 66.2

C. Timeliness of Orders

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	163 70.2%	105 64.4%	58 35.6%
Group 2 Rank 4-10	69 29.7%	23 33.3%	46 66.7%

Percentage of grouped cases correctly classified = 65.1

D. Planning For Use of Reserves

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	160 67.8%	98 61.3%	62 38.8%
Group 2 Rank 4-10	76 32.2%	32 42.1%	44 57.9%

Percentage of grouped cases correctly classified = 60.2

Continued

Table 5
Discriminant Function Analyses
Continued

E. **Planning: Logistics**

Actual Group		Predicted Group Membership Group 1	Group 2
Group 1 Rank 1-3	132 66.3%	76 57.6%	56 42.4%
Group 2 Rank 4-10	67 33.7%	19 28.4%	48 71.6%

Percentage of grouped cases correctly classfied = 62.3

F. **Planning: Subordinate Units**

Actual Group		Predicted Group Membership Group 1	Group 2
Group 1 Rank 1-3	136 65.4%	90 66.2%	46 33.8%
Group 2 Rank 4-10	72 34.6%	22 30.6%	50 69.4%

Percentage of grouped cases correctly classified = 67.3

G. **Awareness of Enemy Capabilities**

		Predicted Group Membership Group 1	Group 2
Group 1 Rank 1-3	180 68.2%	84 46.7%	96 53.3%
Group Rank 4-10	84 31.8%	15 17.9%	69 82.1%

Percentage of grouped cases correctly classified = 57.9

The research findings for the judgmental planning share variables can be summarized as:

- The probability of effective combat performance is best enhanced during planning phases by emphasizing proper use of subordinate units.
- The quality of the plan is positively associated with the combat effectiveness of a unit.
- The timeliness of orders during planning phases is positively associated with the probability of effective combat performance.
- Logistics planning shows a small but statistically significant association with effective combat performance.
- Planning for the effective positioning and usage of reserve forces shows a small but statistically significant association with effective combat performance.
- Awareness of enemy capabilities has a statistically significant relationship to effective combat performance, but appears less important when compared with active planning variables such as timeliness of orders.
- While the quality of information is statistically positively associated with effective combat performance, its contribution, *per se*, is slight. There may be specific situations in which it is important, but active planning variables and awareness of enemy capabilities are better predictors of effective performance.
- The set of judgmental planning variables is moderately intercorrelated, suggesting that these phenomena do not occur independently -- units that plan well for the use of subordinates also tend to issue timely orders, do good logistics planning, and so forth.

CORRELATIONS BETWEEN JUDGMENTAL AND HISTORICAL VARIABLES

Before leaving the planning phase, it is necessary to look for historical variables that can be used as surrogate variables for the judgmental planning variables. Table 6 provides the relevant Pearson product-moment correlations. Awareness of enemy capabilities is associated with

TABLE 6

Correlations Between Historical Planning Variables and Judgmental Planning Variables

ID#	Variable	Planning Level			Hasty/Deliberate		
		r	n	s	r	n	s
C10	Quality of information	.30	41	.04	.25	40	.05
C12	Plan quality	.25	41	.06	.28	40	.05
C34	Timeliness of orders	.13	41	.22	.12	40	.22
C36	Plan: Reserves	.25	41	.06	.08	40	.32
C38	Plan: Logistics	.12	39	.24	.18	38	.14
C40	Plan: Subordinate Units	.27	41	.04	.05	40	.14
C42	Awareness of enemy	.37	41	.009	.27	40	.05

the level of planning ($r = .37$), as are quality of information ($r = .30$) and planning for the use of subordinate units ($r = .27$). Overall plan quality and planning for the use of reserves approach significant relationships. Plan quality, awareness of enemy capabilities, and quality of information show relationships with the nature of the planning process. These are reasonable relationships, suggesting that higher headquarters are better informed about the battlefield and have greater planning resources while deliberate planning results in better efforts and involves better information than hasty planning. However, except perhaps for the information variables, the two historical planning variables appear unlikely to provide a meaningful surrogate indicator for judgments about planning activities.

CHAPTER 5. PREPARATORY FIRES

The first battlefield activity in offensive operations is preparatory fire. As used here the concept includes any and all forces bringing fire on the battlefield prior to the actual infantry attack -- air, artillery, or naval gunfire. Unfortunately, data are seldom available on the amount of fire placed on a front as narrow as that of a battalion in the attack. Accordingly, even the historical variables coded for this function are, basically, judgments. In this case, however, they are judgments based on the reading of detailed data about each of the engagements, including the after action reports filed by the units. The research team, composed primarily of combat veterans and led by retired senior officers, assessed the quality of the fires delivered in the preparatory phases based on the best available sources.

Table 1 shows that the same basic relationship was found both for the officer coder preparatory fires variable (preparatory air interdiction) and the historical assessments of the research team. There is no statistical association between any specific type of preparatory fire (air, artillery, mortar, naval gunfire, or overall fire) and combat effectiveness ratings. Moreover, the officer coders provided a relatively low estimate (mean 2.5) of the importance of preparatory air interdiction in determining the outcome of the engagements they coded.

To avoid an error based on over-aggregation, the variables were subjected to closer examination. The discriminant function analysis of the officer coder assessments of air preparation (Table 2) showed relatively small predictive power (53.6 percent of cases coded correctly). Moreover, only 153 codings of the variable as "important" were registered.

When the historical variables were subjected to somewhat closer scrutiny (Table 3), however, an interesting pattern appeared. The effect of

TABLE 1

Pearson Product-moment Correlation of Combat Effectiveness With Preparatory Fires Variable

A. Judgmental Variable

ID#	Variable	r	r^2	n	s	Mean Importance
C82	Preparatory Interdiction	-.05	.00	153	.28	2.5

B. Historical Codings

H94	Softening -- Bombers	.03
H96	Softening -- Fighters	-.08
H98	Softening -- Helo	.05
H100	Softening -- Artillery	.09
H102	Softening -- Mortars	-.01
H104	Softening -- Naval	-.08
H108	Softening -- All	.04
H95	Immediate -- Bombers	.02
H97	Immediate -- Fighters	.02
H99	Immediate -- Helo	.08
H101	Immediate -- Artillery	-.01
H103	Immediate -- Mortars	-.06
H105	Immediate -- Naval	-.06
H109	Immediate -- All	.09
H110	Duration of Prep Fires	-.02

TABLE 2

Discriminant Function Analysis of Combat Effectiveness Based on Judgmentally Derived Air Preparation Variable

Actual Group		Predicted Groups Group 1	Group 2
Group 1 Rank = 1-3	107 69.9%	60 56.1%	47 43.9%
Group 2 Rank = 4-10	46 30.1%	24 52.2%	22 47.8%

Percentage of grouped cases correctly classified = 53.6%

TABLE 3

Association of Historical Variables Related to Preparatory Fires With Combat Effectiveness

A. Softening up - Bombers

		None	Poor/Fair	Good	Excellent	
Mean Outcome Scores	1-2.79	8	2	6	0	16
	2.80 +	12	3	2	3	20
		20	5	8	3	36

Too few observations to permit statistical summarization.

B. Softening up - Fighters

		None	Poor/Fair	Good	Excellent	
Mean Outcome Scores	1-2.79	7	0	7	4	18
	2.80 +	11	4	3	2	20
		18	4	10	6	38

Too few observations to permit statistical summarization.

C. Softening up - Artillery

		None	Poor/Fair	Good	Excellent	
Mean Outcome Scores	1-2.79	12	4	1	1	18
	2.80 +	11	1	0	6	18
		23	5	1	7	36

Too few observations to permit statistical summarization.

D. Softening up - Overall

		None	Poor/Fair	Good	Excellent	
Mean Outcome Scores	1-2.79	6	1	10	1	18
	2.80 +	9	2	3	4	18
		15	3	13	5	36

Too few observations to permit statistical summarization.

E. Duration of Preparatory Fires

		None	1 hr.	1-24 hrs.	24 hrs. +	
Mean Outcome Scores	1-2.79	4	5	2	7	18
	2.80 +	5	4	3	2	14
		9	9	5	9	32

Too few observations to permit statistical summarizations.

bombers in softening up an attack area (3A) is a good example. In the absence of any use of bombers to soften an attack area, the chances were approximately 40 percent that combat effective performance would follow. Poor or fair softening do not change that probability. A dramatic reversal occurs, however, if good softening occurs -- a 75 percent chance of effective performance is observed. When excellent softening occurs, however, there is a high probability of poor combat performance. This suggests that heavy and aggressive softening by bombers is associated with very difficult missions and is not, in itself, likely to change the situation. This type of a "curvilinear" pattern of influence is not detected by the "linear" techniques used in Table 1, which explains the low correlation coefficients.

The use of fighters in a softening up role appears to be somewhat more effective. Table 3B shows a 39 percent chance of effective combat performance when no preparatory strikes were made. Poor/fair strikes show only four cases, all poor combat performance. Taken together these two categories show a 32 percent probability of effective combat (7 ÷ 22). The good and excellent categories, taken together, show a 69 percent probability of effective performance (11 ÷ 16). Fighter support does not, however, show the ineffective tail. Either they are not used to soften up particularly difficult targets or they are more effective at damaging them than other forms of preparatory fires.

The more familiar pattern reappears in 3C (artillery fire). There is little difference between cases in which no artillery softening up is included. Poor/Fair and Good appear to be associated with success. Heavy, intensive artillery preparations, like excellent bomber preparations, are associated with ineffective combat performance. Here again, the assumption that greater efforts are made with preparatory fires for inherently difficult missions seems important. These fires do not, it seems, in themselves, change the difficult situation. The overall

assessment of softening up fires (3D) is highly consistent with this interpretation.

- Fighter aircraft provide the form of preparatory fire having the most dramatic impact on the probability of combat effective performance.

- Bomber aircraft used well have positive impact on the probability of combat effective performance in all except the most difficult situations.

- Bombers used in extremely difficult situations do not increase the probability of effective combat, regardless of how well they are used.

- Artillery preparations used moderately well in all except difficult combat situations have a positive impact on the probability of combat effective performance.

- Artillery preparations do not, in themselves, increase the probability of effective combat performance in difficult combat situations.

- Overall, preparatory fires, used well, increase the probability of combat effective performance.

- Preparatory fires, except perhaps fighter aircraft, do not increase the probability of effective combat performance in difficult situations.

The final variable worthy of examination is the duration of preparatory fires. This, too, suggests an interesting pattern. Only preparatory fires that last more than a full day have a noticeable influence on the probability of combat effective performance. Hence:

- Preparatory fires, to be a positive influence on the probability of combat effectiveness, must be extended -- perhaps 24 hours in length.

CHAPTER 6: BATTALION ACTIONS DURING THE OPERATION

INTRODUCTION

Regardless of how well (or poorly) the unit has been organized, trained, and equipped, and regardless of how well the plans have been made or preparatory fires executed, experienced combat commanders maintain that the actions of the unit itself, once it enters a hostile environment, are the single most important determinant of military mission accomplishment. This chapter examines the evidence related to battalion actions during operations. Table 1 identifies the variables. Most are judgmental, in part because of the difficulty of keeping detailed records about actions during combat and in part because so many intangible concepts (morale, discipline, aggressiveness, and so forth) are important elements of unit effectiveness.

JUDGMENTAL VARIABLES

Several types of judgmental variables were considered. Summary measures of the unit's performance (overall effectiveness of execution, implementation of the principles of war), examination of the abilities to move (maneuver, security on the move), shoot (use of fire), and communicate (linkages to external command units, effectiveness of communications), were considered along with intangible, command related factors (reaction to unexpected situations, morale during the operation, discipline, aggressiveness, initiative, resourcefulness) and the impact of casualties on the unit's performance. Measures of procedures and preparation (adequacy of night positions and preparation of positions) were also examined.

The variables assigned the greatest importance (2.9 on a scale with a limit of 3.0) by the officer coders were overall effectiveness of execution,

TABLE 1

Pearson Product-moment Correlation of Combat Effectiveness With Actions of the Battalion During Operations

A. Judgmental Variables

ID#	Variable	r	r^2	n	s	Mean Importance
C52	Overall effectiveness of execution	-.53	.27	282	.001	2.9
C54	Implementation of principles of war	-.53	.27	195	.001	2.8
C74	Maneuver	-.46	.21	258	.001	2.7
C76	Use of fire	-.39	.15	227	.001	2.9
C90	Adequacy of night positions	-.29	.09	200	.001	2.6
C92	Preparation of positions	-.30	.09	118	.001	2.6
C94	Security on the move	-.44	.19	127	.001	2.7
C98	Linkages to external units or commands	-.28	.08	214	.001	2.8
C100	Reaction to unexpected situations	-.43	.19	278	.001	2.8
C102	Morale during the operation	-.21	.04	165	.003	2.8
C104	Discipline	-.38	.14	170	.001	2.9
C106	Aggressiveness	-.38	.15	270	.001	2.8
C108	Initiative	-.40	.16	261	.001	2.8
C110	Resourcefulness	-.47	.22	245	.001	2.8
C112	Casualty levels (impact on effectiveness)	-.30	.09	239	.001	2.5
C128	Effectiveness of Communications	-.32	.10	182	.001	2.8

B. Historical Variables

ID#	Variable	r
H111	Intensity of fire from organic crew served weapons	-.05
H125	Effectiveness of fire from organic crew served weapons	.04
H169	Strength of linkage: Company Commander to platoons	-.06
H170	Strength of linkage: Battalion Commander to Companies	.08
H171	Strength of linkage: Battalion to Support Fires	-.04
H172	Strength of linkage: Battalion to adjacent Battalions	-.07
H173	Strength of linkage: Battalion to Regiment	.14

use of fire, and discipline. Those rated least important were casualty levels as they impact performance (2.5), adequacy of night positions (2.6), and preparation of positions (2.6). All others were assigned weights in the 2.7-2.8 range, which is typical for all judgmental variables in the data set.

There is little of a surprising nature in these ratings. Overall effectiveness of execution is a vague concept that ought to be closely associated with ratings of military mission accomplishment. The low weights assigned to adequacy of night positions and preparation of positions may well reflect the large number of offensive operations in the 41 case sample. These two variables were also coded as significant relatively few times -- they are the only ones in this set coded less than 165 times. The pattern of important scores (tightly grouped around 2.7-2.8) again emphasizes the fact that:

- Officer coders distinguish the relative importance of judgmental variables only to a small extent. They tend to rate all combat related functions as equally important.

Turning to the measure of association between the judgmental variables and combat effectiveness (r and r^2), a number of interesting factors emerge. First, overall measures of performance (effectiveness of execution and implementation of the principles of war) have the strongest association with combat effectiveness. This is not surprising, it even helps the research team gain confidence in the validity of the combat effectiveness measure utilized. However, this finding is also not very useful -- it can be seen as a tautology that organizations that perform well and in accordance with the agreed principles tend to be effective. In an effort to determine whether insight might result from disaggregating the principles of war, a check was made to see how well the overall implementation of principles of war intercorrelates with the nine individual principles (Table 2). Strong intercorrelations were found except

TABLE 2

Pattern of Intercorrelation Among
Use of Principles of War During Operations

ID#	Variable	C54	C56	C58	C60	C62	C64	C66	C68	C70	C72
C54	Overall	1.00									
C56	Objective	.74	1.00								
C58	Offensive	.70	.69	1.00							
C60	Map	.71	.58	.70	1.00						
C62	Economy of Force	.65	.54	.60	.65	1.00					
C64	Maneuver	.78	.73	.67	.65	.64	1.00				
C66	Unity of Command	.56	.60	.58	.61	.59	.54	1.00			
C68	Security	.60	.54	.50	.58	.57	.60	.61	1.00		
C70	Surprise	.48	.50	.43	.45	.54	.58	.43	.58	1.00	
C72	Simplicity	.64	.63	.61	.58	.55	.58	.61	.55	.47	1.00

with the surprise principle, which is examined in Chapter 13 along with other variables related to shock and surprise. Hence, a valid finding is:

- Measures of effective performance by the unit during the operation show the strongest pattern of association of any judgmental measures with combat effectiveness. Hence, the research demonstrates that the actions of the unit itself, rather than any of the training, equipment, planning, support fires, preparation or other factors is the strongest influence on the success of an operation.

The question of which specific activities constitute effective performance can be answered in two different ways. On the one hand, specific activity variables that correlate most strongly with the combat effectiveness measure can be seen as the most significant. In addition, however, crucial activities should also intercorrelate highly with the two overall measures of performance by the battalion during the action (Table 3).

Based on these two criteria, there are two significant clusters of activity -- adaptive behavior variables and movement variables. The strongest specific association between a judgmental variable and the combat effectiveness measure is "resourcefulness" (Table 1, $r = -.47$, $r^2 = .22$), which also shows a strong relation to overall unit effectiveness (Table 3, $r = .64$) and implementation of the principles of war (Table 3, $r = .64$). Strong relationships also exist for "reaction to unexpected situations" with combat effectiveness ($r = .-43$, $r^2 = .19$) unit effectiveness ($r = .63$) and principles of war ($r = .53$). The two variables -- resourcefulness and reaction to the unexpected -- show a powerful intercorrelation $r = .80$). Initiative is also a member of this cluster (r with resourcefulness = .78, r with combat effectiveness = -.40). These three variables represent the idea of adaptive behavior -- the ability of an organization to identify a situation and alter behavior in order to deal with it in a more effective way. This factor was identified in Phase I research, based

TABLE 3

Pattern of Intercorrelation Among Judgmental
Variables of Battalion Actions During Operations

ID#	Variable	C52	C54	C74	C76	C90	C92	C94	C98	C100	C102	C104	C106	C108	C110	C112	C128
C52	Unit Effectiveness	1.00															
C54	Principles of War	.76	1.00														
C74	Maneuver	.68	.72	1.00													
C76	Use of Fire	.55	.47	.48	1.00												
C90	Night Positions	.46	.51	.55	.40	1.00											
C92	Position Preparation	.51	.49	.55	.42	.73	1.00										
C94	Security on the Move	.58	.56	.68	.43	.54	.66	1.00									
C98	External Linkage	.40	.36	.42	.41	.32	.38	.66	1.00								
C100	Reaction to Unexpected	.63	.53	.64	.61	.32	.47	.54	.40	1.00							
C102	Morale (During)	.48	.42	.44	.48	.32	.45	.41	.33	.46	1.00						
C104	Discipline	.48	.53	.42	.47	.28	.44	.33	.42	.53	.65	1.00					
C106	Aggressiveness	.53	.47	.46	.54	.29	.36	.48	.26	.65	.48	.61	1.00				
C108	Initiative	.52	.56	.56	.56	.32	.44	.55	.32	.70	.52	.57	.75	1.00			
C110	Resourcefulness	.64	.64	.64	.64	.36	.56	.62	.35	.80	.52	.59	.67	.78	1.00		
C112	Casualty Impact	.60	.55	.50	.44	.39	.42	.48	.38	.63	.55	.61	.38	.49	.64	1.00	
C128	Communications	.42	.37	.43	.46	.35	.41	.77	.75	.43	.35	.35	.26	.33	.43	.41	1.00

largely on the observation of field exercises, as the single most important activity that a combat unit must carry out. Finding it using a totally different research method (judgmental coding by combat veterans) lends great credibility and validity to the argument. Hence, the finding:

- The single most important activity that a combat unit must execute is adaptive behavior. The ability to recognize a situation and react to it (or the ability to learn on the battlefield and act on the learning) has the strongest association with combat effectiveness of any specific function.

The second strong cluster identified in the correlation tables consists of movement variables. Maneuver has a solid relationship to combat effectiveness (Table 1, $r = -.46$, $r^2 = .21$) as well as with unit effectiveness (Table 3, $r = .68$) and principles of war (Table 3, $r = .72$). Security on the move has a similar pattern with combat effectiveness ($r = .-44$, $r^2 = .19$), unit effectiveness ($r = .58$), and principles of war ($r = .56$). The two variables -- maneuver and security on the move -- also show a strong intercorrelation ($r = .68$). Hence, the physical movement of the unit and the skill with which it is handled represents a major component of the activities that must be executed to achieve success. Note, however, that they are not independent of the adaptive behavior variables -- with intercorrelations above .60 being the rule rather than the exception.

- Maneuver and security on the move show strong association with effective combat performance. These skills are nearly as important as adaptive behavior and may be a major component of the adaptive behavior activities.

The next most important variable is use of fire, with an r of $-.39$ and r^2 of .15 for combat effectiveness (Table 1) and a moderate association with the unit effectiveness ($r = .55$) and principles of war ($r = .47$)

variables. While related to adaptive behavior and movement variables at the r = .5 to .6 level, this variable has no other close associates.

- The use of fire is an important, statistically significant activity in determining the probability of combat effective performance.

The next set of variables are related to the actions by the unit commander and reflect his leadership qualities. Discipline (r = .-38, r^2 = .14) and aggressiveness (r = -.38, r^2 = .15) show reasonable correlation with combat effectiveness and moderate (.4 - .5) relationships to unit effectiveness and principles of war variables. They intercorrelate with one another (r = .61), with morale during the operation, and with the adaptive behavior variables. They may also form a component of adaptive behavior, but are really indirect measures of leadership per se:

- Leadership variables such as aggressiveness and discipline show a moderately strong, statistically significant association with combat effectiveness.

Somewhat surprisingly, communications related activities showed a relatively weak association with the combat effectiveness measure. Linkages to external units and commands is associated with only about 8 percent of the variance in the combat effectiveness measures, while effectiveness of communications shows only about 10 percent variance explained. Moreover, neither of these variables shows strong relationships with either unit effectiveness or implementation of the principles of war. They are related strongly to each other (r = .75) and to security on the move (r = .77 for communications, .66 for external linkages).

- Communications variables show a relatively weak, but statistically significant, association with measures of combat effectiveness.

The other judgmental variables examined also show weak relationships. Adequacy of night positions and preparation of positions show weak but

statistically significant relationships. This is consistent with the expectations of the officer coders and, as noted above, may well be influenced by the selection of cases for the research. Offensive actions, where preparation of positions is relatively unimportant, predominate. A number of the engagements reviewed were less than a full day in length, so overnight positions might not be a factor at all.

More interesting, although difficult to explain, is the relatively weak association between morale during an operation and combat effectiveness. This has a trival amount of variance explained ($r^2 = .04$) and relatively weak associations with other judgmental variables (discipline, where $r = .65$, is the highest by far). It seems that the officer coders see little relationship between the way soldiers feel and their combat effectiveness.

- Morale during an engagement has little or no influence on the probability of combat effective performance by a military unit.

The final judgmental variable, the impact of casualties on effectiveness, also shows relatively little association with combat effectiveness ($r^2 = .09$). It is related to unit discipline ($r = .61$), resourcefulness ($r = .64$) and overall unit performance ($r = .60$), but does not, in itself, show strong association with combat effectiveness. This relatively weak association is somewhat surprising since the variable would seem to be a fairly natural measure of adaptive behavior. One final fact must be noted:

- The pattern of intercorrelation clearly shows that the components of battalion actions during combat are highly intercorrelated. Based on the analyses performed, it is not clear whether it is unlikely that some of the activities will go well unless others do or whether it is impossible to separate them.

DISCRIMINANT FUNCTION ANALYSES

As a check on the validity and reliability of the estimates of relative predictive power by these key judgmental variables, a set of discriminant function analyses were performed (Table 4). The key indicator for these analyses is the percentage of grouped cases correctly classified when the only information known is the predictor variable.

As was seen with correlation techniques, the two general variables -- overall effectiveness of execution and implementation of the principles of war -- were the best predictors, accounting for above three-fourths of the officer codings correctly predicted (Tables 4A and 4B).

The movement variables emerged in this analysis as better predictors than the adaptive behavior variables. Maneuver accounted correctly for 68.3 percent of the cases (Table 4C), and security on the move for 63.0 percent (Table 4F). Reaction to unexpected situations, the best adaptive behavior variable, accounted for 65.4 percent (Table 4H), but resourcefulness (Table 4K) only a disappointing 59.2 percent. Use of fire, with 64.3 percent was clearly an important predictive variable (Table 4D).

Communications variables showed somewhat more strength with external linkages accounting correctly for 61.2 percent of the cases (Table 4G) and effectiveness of communications 59.9 percent (Table 4H). Aggressiveness (60.7 percent, Table 4I) and initiative (Table 4J) showed remarkable consistency. Others, such as adequacy of night position continued to show weak, but statistically measurable, influence on the probability of combat effective performance.

- Discriminant function analyses classified the relative importance of the key functions of a unit during combat. They appear to be:
  - Movement,

TABLE 4

Discriminant Function Analyses of Judgmental
Critical Factors as Predictors of Combat Effectiveness

A. Overall Effectiveness of Execution

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	193 68.4%	146 75.6%	47 24.4%
Group 2 Rank 4-10	89 31.5%	29 32.6%	60 67.4%

Percent of grouped cases correctly classified = 75.1

B. Implementation of Principles of War

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	133 68.2%	103 77.4%	30 22.6%
Group 2 Rank 4-10	62 31.8%	16 25.8%	46 74.2%

Percent of grouped cases correctly classified = 76.4

C. Maneuver

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	176 68.2%	113 64.2%	63 35.8%
Group 2 Rank 4-10	82 31.8%	26 31.7%	56 68.3%

Percent of grouped cases correctly classified = 65.5

D. Use of Fire

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	153 67.4%	105 70.6%	45 29.4%
Group 2 Rank 4-10	74 32.6%	36 48.6%	38 51.4%

Percent of grouped cases correctly classified = 64.3

Continued

Table 4
Discriminant Function Analyses
Continued

E. Adequacy of Night Position

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	136 68.0%	80 58.8%	56 41.2%
Group 2 Rank 4-10	64 32.0%	26 40.6%	38 59.4%

Percent of grouped cases correctly classified = 59.0

F. Security on the Move

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	84 66.1%	46 54.8%	38 45.2%
Group 2 Rank 4-10	43 33.9%	9 20.9%	34 79.1%

Percent of grouped cases correctly classified = 63.0

G. Linkages to External Units or Commands

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	145 67.8%	83 57.2%	62 42.8%
Group 2 Rank 4-10	69 32.3%	21 30.4%	48 69.6%

Percent of grouped cases correctly classified = 61.2

H. Reaction to Unexpected Situations

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	187 67.3%	139 74.3%	48 25.7%
Group 2 Rank 4-10	91 32.7%	40 44%	51 56%

Percent of grouped cases correctly classified = 65.4

Continued

Table 4
Discriminant Function Analyses
Continued

I. Aggressiveness

Actual Group		Predicted Group Membership: Group 1	Group 2
Group 1 Rank 1-3	188 69.6%	103 54.8%	85 45.2%
Group 2 Rank 4-10	82 30.4%	21 25.6%	61 74.4%

Percent of grouped cases correctly classified = 60.7

J. Initiative

Actual Group		Predicted Group Membership: Group 1	Group 2
Group 1 Rank 1-3	180 69.0%	92 51.1%	88 48.7%
Group 2 Rank 4-10	81 31.0%	15 18.5%	66 81.5%

Percent of grouped cases correctly classified = 60.5

K. Resourcefulness

Actual Group		Predicted Group Membership: Group 1	Group 2
Group 1 Rank 1-3	170 69.4%	86 50.6%	84 49.4%
Group 3 Rank 4-10	75 30.6%	16 21.3%	59 78.7%

Percent of grouped cases correctly classified = 59.2

L. Effectiveness of Communications

Actual Group		Predicted Group Membership: Group 1	Group 2
Group 1 Rank 1-3	118 64.8%	69 58.5%	49 41.5%
Group 2 Rank 4-10	64 35.0%	24 37.5%	40 62.5%

Percent of grouped cases correctly classified = 59.9%

- Adaptive behavior,
- Use of fire,
- Communications, and
- Leadership.

- These analyses did not help to clarify the relationship among these specific activity types. Movement is one component of adaptive behavior, use of fire may be another, and so forth.

HISTORICAL VARIABLES

Returning to Table 1B, the historical measures of activity during an engagement showed quite weak and not very interesting patterns of association with the measure of combat effectiveness. This is not surprising, given the difficulty of measuring for historical variables during these phases of combat. The absence of clear, linear relationships between the effectiveness of fire measure and the strength of linkage measures is consistent with the findings elsewhere. Effectiveness measures were poorly related to performance when support fire was examined. Similarly, internal and external linkages showed surprisingly weak associations when the judgmental variables influencing combat effectiveness were studied.

The lack of a linear relationship between intensity of fire from organic crew served weapons and the combat effectiveness measure warranted closer examination. In the supporting fires analyses, these fire intensity measures often revealed association when examined in detail. Table 5 shows associational breakdowns of the fire intensity and effectiveness variables. When examined in detail, fire intensity shows a clear, but statistically nonsignificant trend. If no fire is provided or if fire is moderate, the probability of effective combat performance is 33 percent (3 ÷ 9). Where intense fire from organic crew served weapons is provided, the probability of effective performance is 59 percent (17 ÷ 29).

TABLE 5

Association of Historical Variables Related
to Battalion Actions With Combat Effectiveness

A. Intensity of Fire From Organic Crew Served Weapons

		None	Moderate	Heavy	
Mean Outcome Scores	1-2.79	0	3	17	20
	2.80 +	2	4	12	18
		2	7	29	38

Chi-square = 2.9   2 degrees of freedom   s = .23

B. Effectiveness of Fire From Organic Crew Served Weapons

		None	Poor/Fair	Good	Excellent	
Mean Outcome Scores	1-2.79	0	5	5	9	19
	2.80 +	2	2	7	7	18
		2	7	12	16	37

Too few cases to support realistical summary.

Hence, there is a trend, albeit not a statistically significant one. No such trend is found in the effectiveness table (5B).

- Intensity of fire from organic, crew served weapons shows a moderate, statistically nonsignificant, association with the combat effectiveness measure.

The other historical variables proved to have too few reliably coded cases to support this type of more detailed analysis.

A final observation is in order.

- In evaluating activities of a battalion during an engagement, the difficulties of obtaining directly measurable factors and the number of intangibles to be evaluated make judgmental variables more useful than empirical measures.

CHAPTER 7. SUPPORTING FIRES

INTRODUCTION

In addition to the activities controlled or coordinated within the infantry battalion, there are a number of other functions that influence the effectiveness of combat performance. Supporting fires are one of the most directly related to the engagements themselves. An effort was made to collect data on a range of different ways to deliver supporting fires on the battlefield -- artillery, naval gunfire, close air support, and armor -- as well as to assess the overall impact of the set of fires brought to bear during each engagement.

As with preparatory fires, the research team found it all but impossible to collect specific data on the numbers of rounds fired (or missions flown) in support of individual battalions. Records are simply not kept on the relatively narrow fronts or at the level of detail that such analysis requires. As a result, the major sets of variables, both judgmental and historical, are really assessments of the fire support received as they are seen by informed observers.

Table 1 shows the full set of variables considered. Judgmental variables (coded by officer participants) were available for all four major means of fire delivery. Two of the variables -- naval gunfire and armor support -- are cited relatively infrequently by officer coders as critical factors in determining combat effectiveness. This is consistent with the Phase I research finding that these types of support have been available to Marine Corps battalions in only a limited number of the historical situations under analysis. Moreover, the officer coders assigned armor support one of the weakest overall importance values (2.3) in the entire data set, and a relatively weak value to naval gunfire.

TABLE 1

Pearson Product-moment Correlation of Combat Effectiveness With Supporting Fires

A. Judgmental Variables

ID#	Variable	r	r^2	n	s	Mean Importance
C78	Support Artillery	-.23	.06	214	.001	2.8
C80	Naval Gunfire	-.16	.03	117	.001	2.5
C84	Close Air Support	-.29	.09	181	.001	2.7
C96	Armor Support	-.14	.02	142	.05	2.3

B. Historical Variables

H113	Intensity: Artillery	.04
H115	Intensity: Close Air Support	-.02
H117	Intensity: Tank Fires	-.11
H119	Intensity: Naval Gunfire	-.13
H123	Intensity: Overall Fire	-.04
H127	Effectiveness: Artillery	.02
H129	Effectiveness: Close Air Support	-.05
H131	Effectiveness: Tank Fires	-.08
H133	Effectiveness: Naval Gunfire	-.05
H137	Effectiveness: Overall Fires	-.07
H139	Number Batteries: Direct Support	-.17
H141	Number Batteries: Indirect Support	-.00
H143	Total Friendly Batteries	.05

Because of the large number of assessments made, all four of the judgmental variables show statistically significant relationships with combat effectiveness, but the percentages of variance explained (r^2) are quite small. Only close air support appears to be a factor worthy of attention, with artillery being marginally so. All the signs on the correlation coefficients are, however, in the correct direction -- little support is associated with poor combat performance (high rankings).

The historical variables under analysis can be divided into three groups -- assessments of the intensity of supporting fires, assessments of the effectiveness of supporting fires, and factual data on the amount of artillery support assigned to the battalion. As the small values for r indicate, none of these variables show simple linear associations with combat effectiveness.

DISCRIMINANT FUNCTION ANALYSES

As in other chapters, discriminant function analyses were performed to confirm the relative prediction power of the set of judgmentally derived variables. Table 2 indicates that they confirmed the patterns identified by the simple correlation technique. Close air support proved to have the greatest predictive power. Almost two-thirds of the combat effectiveness codings could be correctly predicted solely on the basis of the close air support performance coding. This finding is a confirmation of a trend identified in Phase I research (although the power of the variable is somewhat reduced in the Phase II work).

- Close air support is the single form of supporting fire most likely to increase the probability of effective combat performance.

The confirmation of support artillery as a predictor of effective combat performance (three of five cases correctly projected) is somewhat

TABLE 2

Discriminant Function Analyses of Judgmental
Critical Factors as Predictors of Combat Effectiveness

A. Support Artillery

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	148 69.2%	90 60.8%	58 39.2%
Group 2 Rank 4-10	66 30.8%	24 36.4%	42 63.3%

Percentage of grouped cases correctly classified = 61./%

B. Naval Gunfire

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	87 74.4%	45 51.7%	42 48.3%
Group 2 Rank 4-10	30 25.6%	12 40.0%	18 60.0%

Percentage of grouped cases correctly classified = 53.8%

C. Close Air Support

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	115 63.5%	83 73.2%	32 27.8%
Group 2 Rank 4-10	66 36.5%	30 45.5%	36 54.5%

Percentage of grouped cases correctly classified = 65.8%

D. Armor Support

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	99 69.7%	45 45.5%	54 54.5%
Group 2 Rank 4-10	43 30.2%	14 32.6%	29 67.4%

Percentage of grouped cases correctly classified = 52.1%

different than Phase I or preparatory fires findings, but is consistent with the Pearson product-moment correlation.

- Support artillery performance during an engagement is associated with a higher probability of effective combat performance.

The other two variables -- naval gunfire and tank fires -- do not show a robust relationship to combat effectiveness in this general analysis:

- Naval gunfire performance shows a statistically significant, but weak, association with combat effective performance.
- Armor support performance shows a statistically significant, but weak, association with combat effective performance.

HISTORICAL VARIABLES MEASURING INTENSITY OF FIRES

A more detailed examination of the pattern of association between effective combat performance and the historical measures of support fires reveals that:

- Most measures of the intensity of supporting fires show patterns of association with combat effectiveness,
- No measures of the effectiveness of supporting fires show patterns of association with combat effectiveness, and
- Some measures of support artillery available show weak association with combat effective performance.

The detailed breakdown of the historical data's relationship with combat effectiveness is shown in Table 3. The intensity variables are treated first. The data have been spread out into eight cells in most cases so that curvilinear relationships, like those found in supporting fires, will not be missed.

TABLE 3

Association of Historical Measures of Supporting Fires With Combat Effectiveness

A. Intensity: Artillery

		None	Low	Moderate	High	
Mean Outcome Scores	1-2.79	0	3	5	11	19
	2.80 +	2	2	3	11	18
		2	5	8	22	

Too few observations to permit statistical summarization

B. Intensity: Close Air Support

		None	Low	Moderate	High	
Mean Outcome Scores	1-2.79	1	1	11	6	19
	2.80 +	3	4	4	7	18
		4	5	15	13	37

Too few observations to permit statistical summarization

C. Intensity: Tank Fires

		None	Low	Moderate	High	
Mean Outcome Scores	1-2.79	2	5	8	4	19
	2.80 +	10	1	6	2	19
		12	6	14	6	38

Too few observations to permit statistical summarization

D. Intensity: Naval Gunfire

		None	Low	Moderate	High	
Mean Outcome Scores	1-2.79	9	0	5	5	19
	2.80 +	14	1	2	1	18
		23	1	7	6	37

Too few observations to permit statistical summarization

E. Intensity: All Fires

		None	Moderate	High	
Mean Outcome Scores	1-2.79	0	5	14	19
	2.80 +	2	7	8	17
		2	12	22	36

Too few observations to permit statistical summarization

Continued

Table 3
Association of Historical Measures
Continued

F. Effectiveness: U.S. Artillery

		None	Poor	Good	Excellent	
Mean Outcome Scores	1-2.79	1	1	7	9	18
	2.80 +	3	0	7	10	20
		4	1	14	19	38

Too few observations to permit statistical summarization

G. Effectiveness: Close Air Support

		None	Poor	Good	Excellent	
Mean Outcome Scores	1-2.79	1	6	6	6	19
	2.80 +	5	4	5	6	20
		6	10	11	12	39

Too few observations to permit statistical summarization

H. Effectiveness: Tank Fires

		None	Poor	Good	Excellent	
Mean Outcome Scores	1-2.79	6	2	5	6	19
	2.80 +	13	0	3	3	19
		19	2	8	9	38

Too few observations to permit statistical summarization

I. Effectiveness: All Fires

		None	Poor	Good	Excellent	
Mean Outcome Scores	1-2.79	0	3	8	10	21
	2.80 +	1	3	8	8	20
		1	6	16	18	41

Too few observations to permit statistical summarization

J. Direct Support Batteries

		0	1	2	3	4+	
Mean Outcome Scores	1-2.79	3	6	4	3	1	17
	2.80 +	0	9	3	1	3	16
		3	15	7	4	4	33

Too few observations to permit statistical summarization

Continued

Table 3
Association of Historical Measures
Continued

K. Total Support Batteries

		1	2	3	4	5-8	9+	
Mean Outcome	1-2.79	0	2	5	3	2	5	17
Scores	2.80 +	1	2	2	1	3	2	11
		1	4	7	4	5	7	28

Too few observations to permit statistical summarization

Artillery shows a relationship similar to that seen in the preparatory fires' analyses, but more favorable. In the absence of artillery support (only two cases), no positive outcomes occurred. Low and moderate support show a small positive tendency. Intensive artillery, representing the bulk of the cases (22) where an assessment was possible, split evenly. Hence,

- Artillery tends to be very intense, particularly in heavy combat, but artillery intensity, in and of itself, is not likely to increase the probability of effective combat performance.

Close air support (2B) is a textbook case of the curvilinear relationship. The absence of close air support or its low use are clearly associated with poor combat performance. The chance of effective performance when these categories are combined is only about 22 percent. When moderate close air support is used, a decisive edge seems to be present -- the chance of effective performance jumps to 73 percent. This edge is not present, however, in high intensity cases, where only 46 percent of the situations are rated as relatively effective. Intense close air support is only made available, however, in difficult situations, so the inference is that:

- Intense close air support is not, in itself sufficient to increase the probability of effective combat in difficult situations, however

- Moderate close air support is associated with effective combat performance and little or no close air support is associated with poor combat effectiveness. These two categories probably encompass the bulk of nonintense battlefield situations.

Tank fires (3C) show a clear positive association with effective combat performance, but do not seem to contrast with the intensity of fire but rather with the absence of armor. A 20 percent chance of effectiveness

without armor turns into a 65 percent chance of effective performance with armor. Low intensity, however, is the strongest armor fire category (suggesting the familiar curvilinear pattern is present to some extent). The proper inference seems to be:

- The presence of a tank-infantry team on the battlefield, rather than the relative effectiveness of tank fires, is associated with combat effective performance.

Naval gunfire (3D) has a similar pattern. The single case where naval gunfire was present but not intense was a poor effectiveness case. However, the chances of effective performance proved to be almost 77 percent when moderate or highly intense naval gunfire was used and only about 38 percent when it was unavailable or used little. The absence of a significant linear correlation proved to be related to the number of "none available" cases. Hence,

- Moderate and high intensity naval gunfire are associated with an increase in the probability of combat effective performance.

There were no cases of low intensity of all fires. The two cases of no fire support were poor performance while moderate intensity was associated with somewhat poor effectiveness and high intensity with a nearly two-thirds chance of effective performance (versus about 53 percent chance in the 36 cases for which reliable ratings were obtained). The curvilinear pattern found in close air support and suggested in some of the other variables is apparently overcome in this integrated analysis.

- Support fires intensity shows a moderate, but not statistically significant, tendency to increase the probability of effective combat performance.

Historical Variables Measuring Effectiveness of Fires

Few interesting patterns emerge when the historical assessments of supporting fires effectiveness are examined in detail. The presence of artillery is apparently marginally better than its absence (Table 3F), the presence of air support shows a similar situation (3G) as does the overall effectiveness of fires (3I).

The one relatively clear pattern is in the effectiveness of tank fires. In their absence, the chances of effective combat performance are about 31 percent, while poor, good and, excellent tank fire effectiveness aggregate to a 68 percent probability of effective performance. Here, as with the intensity measure, the presence of a tank-infantry team is a much more important factor than the tank fire.

AVAILABLE ARTILLERY

The historical data related to number of artillery batteries, both in direct support and available for support, were also reviewed. No particular trend is discernable in either set of information (Tables 3J and 3K). Hence,

- The number of artillery batteries available to support a battalion does not, in itself, influence the probability of effective combat performance.

An argument could be made for a curvilinear relationship in the "number of direct support batteries" table or for a positive impact in the "total" table, but the number of cases with missing data and the weakness of the relationships when compared with other variables make these inferences risky.

CHAPTER 8. ENEMY STRENGTH AND CAPABILITIES

INTRODUCTION

In the discussion of alternative measures of combat effectiveness, (Chapter 2), the measure that took enemy capabilities and terrain into account tended to correlate only weakly with the generalized measure of combat effectiveness. Obviously, the capabilities and strength of enemy forces on the battlefield are an important element in determining the actions to be taken to achieve effective performance. The research question addressed in this chapter is, "Is there a systematic association between specific enemy capabilities and the combat effective performance of friendly battalions?"

JUDGMENTAL VARIABLE

The set of relevant variables is presented in Table 1. Only one judgmental variable was utilized -- the quality of enemy forces, defined by their type and experience. The officer coders rated the variable as of "normal" importance (2.7) when compared with the other 58 factors they considered, and coded it as a relevant factor in 236 cases, also about normal. Empirically, however, the relationship between the value assigned to the type of enemy force (1 = poor, 6 = excellent) and the effectiveness of the friendly unit, approaches zero. While the large number of codings makes the association almost statistically significant (s = .109 -- if it were .05 or less the research team would have considered it significant), the percentage of variance explained (r^2 = .01) is clearly trivial. Hence, in contrast to the expectation of the officer coders, the research team concluded that:

- Based on a judgmental evaluation of the quality of enemy troops, there is no association between enemy capabilities and performance of friendly units.

TABLE 1

Pearson Product-moment Correlation of Combat Effectiveness With Enemy Strength and Capabilities

A. Judgmental Variable

ID#	Variable	r	r^2	n	s	Mean Importance
C50	Quality (type and experience) of enemy forces	-.08	.01	236	.109	2.7

B. Historical Variables

H63	Type of enemy troops	-.06
H64	Extent of opposition	-.03
H65	Force ratio (enemy/ friendly)	-.02
H66	Availability of artillery	.15
H67	Availability of mortars	-.00
H68	Availability of armor	-.17
H69	Availability of air support	-.11
H70	Availability of air: fired wing	-.02
H71	Availability of air: helicopter	-.08
H72	Availability of naval gunfire	-.05
H74	Availability of anti-air capability	-.10
H75	Availability of anti-air-group fire	.01
H79	Enemy positions: quality	.09
H80	Enemy command and control: quality	.08
H112	Intensity: enemy crew served weapons	.04
H114	Intensity: enemy artillery	-.17
H116	Intensity: enemy close air support	.09
H118	Intensity: enemy tank fires	-.09
H120	Intensity: enemy naval gunfire	-.08
H124	Intensity: overall enemy fires	.01
H126	Effectiveness: enemy crew served weapons	.04
H128	Effectiveness: enemy artillery	-.08
H130	Effectiveness: enemy close air support	-.04
H132	Effectiveness: enemy tank fires	-.10

Continued

Table 1
Pearson Product-moment
Correlation
Continued

ID#	Variable	r	r^2	n	s	Mean Importance
H138	Effectiveness: overall enemy fires	.07				
H140	Number enemy batteries: direct support	-.22				
H142	Number enemy batteries: general support	-.32				
H144	Number enemy batteries: total	-.28				
H174	Severity of opposition: infantry	-.06				
H175	Severity of opposition: artillery	-.21				
H176	Severity of opposition: armor	-.10				
H177	Severity of opposition: air	.05				

HISTORICAL VARIABLES

Most of the information available about enemy strength and capabilities is factual, not really judgmental. Hence, the greatest part of the evidence relevant to enemy capabilities is included in Table 1B. Several types of variables were examined.

- Type of enemy troops based on experience and organization.
- The overall extent of opposition encountered.
- The force ratio (number of people engaged on both sides).
- Availability measures that noted symmetry of capabilities (neither side had the capability, enemy only had it, friendly only had it, both had it).
- Quality of enemy positions.
- Quality of enemy command and control.
- Intensity of fire from enemy forces.
- Effectiveness of fire from enemy forces.
- Amount of enemy artillery available.
- Severity of opposition from different types of capability.

The Phase I research had shown a variety of empirical relationships, including a significant impact of enemy armor presence and a tendency for friendly units to perform effectively against stiff enemy infantry resistance and strong enemy fortifications.

As the measures of association indicate, these relationships largely disappeared when the larger set of coders, greater attention to shock and surprise engagements, and more general missions were introduced in Phase II research. Most of the linear relationships approach zero.

There is an exception to the rule, however. One pattern repeats itself throughout the set of measures -- enemy artillery strength and performance show relatively small, but quite consistent association with friendly combat effectiveness. Intensity of fire from enemy artillery ($r = -.17$), number of enemy batteries in direct support ($r = -.22$), number of batteries in general support ($r = -.32$), and total enemy batteries ($r = -.21$) all show the relationship. However, it is a reversed sign association -- that is, it runs contrary to expectations. The combat effectiveness measure is a rank variable; one is the best possible score, ten the worst. Enemy capabilities show high scores for increased capability or strength. Hence, the two variables should have positive correlation (strong enemy associated with poor performance). The opposite is observed. Hence, the finding,

- There is a tendency for enemy artillery strength and capability to increase the probability of effective combat performance by friendly units.

A number of explanations, none of them completely satisfactory, might be posed. A clue may be found in the small association between the availability of artillery measure (H66) which shows a correct sign and a not quite trivial positive r (.15) with combat effectiveness. This variable assigns low values for situations where enemy forces have no capability (13 cases) and higher ones where both sides have a capability. This implies that U.S. units did poorly against units with <u>no</u> artillery support.

A similar, but weaker relationship may exist for enemy armor. Here availability shows an r of -.17, intensity of tank fires -.09, effectiveness of tank fires -.10, and severity of opposition from armor -.10. In themselves, however, these associations are too weak to support a research finding.

DETAILED EXAMINATION OF HISTORICAL VARIABLES

To resolve some of these ambiguities, a more detailed breakdown of the historical measures of enemy strength and capability was undertaken. Table 2 reports the patterns of association observed between these variables and the combat effectiveness measure.

The first issue examined was the enemy artillery concept. Table 2F shows a breakdown of the intensity of enemy artillery by combat effective performance of friendly units. In the 16 cases where enemy artillery intensity was zero, the probability of effective performance by friendly forces was about 25 percent. Where the enemy had artillery, the chance rose to 70 percent. Where enemy artillery was most intense, it was 75 percent. Despite a small frequency per cell problem, the relationship is strong and would be significant if more observations were present.

A similar pattern emerges when severity of artillery opposition is examined (Table 2J). The chances of effective combat performance by friendly forces is a poor .15 when the enemy has no artillery. When enemy artillery is present this rises to .67 and where it is moderate or high the probability reaches .76. Clearly, then, the artillery relationship is real. This table is statistically significant at the .002 level, although cell frequency again makes the issue of true significance doubtful.

A clue to the interpretation of this relationship appears when the armor variables are examined. Intensity of tank fires, while heavily skewed to the absence of enemy capability, moves from 42 percent to 73 percent effective when the enemy obtains the capability. Severity of armor opposition raises from 47 percent to 64 percent the chance of effective friendly performance. Two findings emerge.

- The presence of enemy armor on the field shows a clear, but statistically nonsignificant tendency

TABLE 2

Association of Historical Variables Related to Enemy Strength and Capabilities With Combat Effectiveness

A. Type of Enemy Troops

		Veterans	Regulars	Average	Irregulars	Hastily Organized	
Mean Outcome Scores	1-2.79	9	5	4	0	3	21
	2.80 +	8	7	2	2	1	20
		17	12	6	2	4	41

Too few cases to support meaningful statistical summary

B. Extent of Opposition

		Light	Moderate	Heavy	
Mean Outcome Scores	1-2.79	2	7	12	21
	2.80 +	5	4	11	20
		7	11	23	41

Chi-square = 2.1 2 degrees of freedom s = .35

C. Enemy Positions: Quality

		Hasty	Prepared	Concrete	
Mean Outcome Scores	1-2.79	6	7	8	21
	2.80 +	3	9	7	19
		9	16	15	40

Chi-square = 1.2 2 degrees of freedom s = .54

D. Enemy Command and Control: Quality

		Poor	Fair	Good	
Mean Outcome Scores	1-2.79	10	11	0	21
	2.80 +	5	13	1	20
		15	24	1	40

Chi-square - 2.74 2 degrees of freedom s = .25

Continued

Table 2
Historical Variables
Continued

E. Intensity: Enemy Crew Served Weapons

Mean Outcome Scores		None	Low	Moderate	High	
	1-2.79	0	1	4	15	20
	2.80 +	2	0	3	13	18
		2	1	7	28	38

Too few cases to support meaningful statistical summary

F. Intensity: Enemy Artillery

Mean Outcome Scores		None	Low	Moderate	High	
	1-2.79	4	4	1	9	18
	2.80 +	12	2	1	3	18
		16	6	2	12	36

Chi-square = 7.7   3 degrees of freedom   s = .05
Cell frequencies make the s value statistically unsound.

G. Intensity: Enemy Tank Fires

Mean Outcome Scores		None	Low	High	
	1-2.79	10	6	2	18
	2.80 +	14	3	0	17
		24	9	2	35

Chi-square = 3.6   2 degrees of freedom   s = .16
Cell frequencies make the s value statistically unsound.

H. Intensity: Overall Enemy Fires

Mean Outcome Scores		None	Low	Moderate	High	
	1-2.79	0	2	7	10	19
	2.80 +	2	1	5	9	17
		2	3	12	19	36

Too few cases to support meaningful statistical analysis.

Continued

Table 2
Historical Variables
Continued

I. Severity of Opposition Infantry

		None	Low	Moderate	High	
Mean Outcome Scores	1-2.79	0	1	3	17	21
	2.80 +	1	3	2	14	20
		1	4	5	31	41

Too few cases to support meaningful statistical analysis.

J. Severity of Opposition: Artillery

		None	Low	Moderate	High	
Mean Outcome Scores	1-2.79	2	2	6	10	20
	2.80 +	11	4	0	5	20
		13	6	6	15	40

Chi-square = 14.8 3 degrees of freedom s = .002

K. Severity of Opposition: Armor

		None	Low	Moderate	
Mean Outcome Scores	1-2.79	14	4	3	21
	2.80 +	16	4	0	20
		30	8	3	41

Chi-square = 3.1 2 degrees of freedom s = .21

to increase the probability of effective combat performance by friendly forces.

- The greater the technological sophistication of the enemy forces on the battlefield the more effective the performance of friendly units.

The term technologically sophisticated is used here in preference to concepts like battlefield intensity because other measures of battle intensity (extent of opposition -- 2B, enemy crew served weapons fire intensity -- 2E, overall intensity of fires -- 2H, and severity of infantry opposition -- 2I) show only slight trends in this direction while artillery and armor show clear trends. The term "technological sophistication" may be too strong, however, given the lack of data and experience with sophisticated air and anti-air capabilities in the data set. The level of sophistication being discovered involves modern combat supported with heavy indirect fire weapons.

One variable that does provide an influence in the expected direction is the historical evaluation of enemy command and control (Table 2D). With poor enemy command and control the probability of effective combat performance by U.S. forces was .67. When the enemy command and control was only fair or good, the probability fell to .44.

- There is a clear, but statistically nonsignificant trend for poor enemy command and control to increase the probability of combat effective performance by friendly forces.

The other variables examined showed no more association in their detailed analyses than they did in the linear correlations reported in Table 1.

- Preparation of enemy positions is unrelated to the effectiveness of combat performance by friendly forces.

- Intensity of fire from enemy crew served weapons shows no clear pattern of association with the

probability of combat effective performance by friendly forces.

There is also a general point to be noted from the data examined in this chapter. While there are patterns of association between a few of the measures of enemy strength and capabilities and combat effectiveness of friendly forces, these measures reflect the relative technological sophistication of the battlefield rather than enemy forces and their actions. Hence,

- Combat effective performance by friendly units, as measured in this study, is generally unrelated to enemy strengths and capabilities. This demonstrates that effective performance depends on the units <u>own</u> actions, not the enemy.

CHAPTER 9. COMBAT SUPPORT

INTRODUCTION

One of the classic arguments about what makes units combat effective is the linkage from combat support to fighting a battle. A famous poem tells us that:

> for want of a nail, a shoe was lost,
> for want of a shoe, a horse was lost,
> for want of a horse, a rider was lost,
> for what of a rider, a message was lost,
> for want of a message, a battle was lost...

It does not necessarily follow, in logic, that for want of a nail a battle was lost for the availability of alternative horses, riders, and so forth might well have made this loss irrelevant. The United States military has, since the Civil War, emphasized material preparedness. Material preparedness is generally credited with influencing the outcome of both World Wars, although it did not dominate the outcome in either Korea or Vietnam.

This chapter examines the role of combat support in influencing the outcome of individual engagements. As in the rest of this study, dramatic findings are the easiest to trace -- cases where specific combat support failures can be tied to damaged combat effectiveness. If combat support is always good (or always bad) it will show no particular relationship with combat effectiveness measures.

As used here, combat support consists of a variety of logistics areas: petroleum, oil, and lubricants (POL); food and water, medical supplies and evacuation; equipment availability; ammunition availability; and delivery of supplies on the battlefield.

JUDGMENTAL VARIABLES

The correlation of the judgmental combat support variables with combat effectiveness are reported in Table 1A. Eight meaningful variables were sought, but the officer coders felt they lacked sufficient information on three of them (barrier materials, special equipment, and maintenance) to provide meaningful codings for more than a few cases. POL supply was coded only 59 times and showed little association. These four variables were excluded from the analyses.

Of the remaining four variables, only a summary measure of logistics support and ammunition supply showed potentially interesting relationships, and they can explain only 6 and 5 percent of the available variance, respectively. Medical evacuation and support shows a weak relationship but explains only a trivial amount of variance, and was rated as relatively unimportant by the officer coders.

Discriminant Function Analyses of Judgmental Variables

To determine the relative predictive capability of the three potentially interesting judgmental variables, discriminant function analyses were performed. Table 2 shows that none of the three could be used to correctly classify as many as 60 percent of the cases. Logistics support was the strongest, with 57 percent correctly classified. Medical evacuation showed a surprising 56 percent, higher than the 55 percent for ammunition supply which had shown a higher simple linear correlation with combat effectiveness. Based on these analyses it was concluded that:

- Judgmental measures of logistics support show a weak, but statistically significant, association with combat effectiveness.
- Ammunition supply shows a weak, but statistically significant, association with combat effective performance.

TABLE 1

Pearson Product-moment Correlation of Combat Effectiveness With Combat Support Variables

A. Judgmental Variable

ID#	Variable	r	r^2	n	s	Mean Importance
C38	Logistics support	-.24	.06	199	.001	2.7
C114	Medical and evacuation support	-.11	.01	167	.078	2.5
C116	Ammunition supply	-.23	.05	166	.002	2.7
C118	Petroleum, oil, and lubrication supply	.09	.00	59	.25	2.2
C120	Food and water supply	.07	.00	100	.26	2.5
C122	Barrier materials	Coded too seldom to calculate				2.1
C124	Special eqiupment	Coded too seldom to calculate				2.4
C126	Maintenance	Coded too seldom to calculate				2.7

B. Historical Variables

H145	Equipment Availability: Landing craft	-.15
H146	Equipment Availability: Shore party equipment	-.14
H147	Equipment Availability: Assault vehicles	.12
H148	Equipment Availability: Ground transport	-.11
H149	Equipment Availability: Weapons	.00
H150	Equipment Availability: Clothing and equipment	.09
H151	Equipment Availability: Communication equipment	-.01
H153	Ammunition Availability: Small arms	-.17
H154	Ammunition Availability: Machine gun	-.03
H155	Ammunition Availability: Artillery	.09
H156	Ammunition Availability: Mortar	.16
H157	Ammunition Availability: Rocket	-.19
H158	Overall Ammunition Problems	-.05
H159	Rations Availability	.30
H160	Medical Supplies	.39
H161	Petroleum, oil, and lubricants	.54
H162	Spare Parts	.34
H164	Supply Delivery	.74
H167	Means of Medical Evacuation	-.10
H168	Speed of Medical Evacuation	.10

TABLE 2

Discriminant Function Analyses of Judgmental Measures of Combat Support With Combat Effectiveness

A. Logistics Support

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	137 68.9%	71 51.8%	66 48.2%
Group 2 Rank 4-10	62 31.1%	19 30.6%	43 69.3

Percent of grouped cases correctly classified = 57.2

B. Medical Evacuation and Support

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	107 64.1%	57 53.3%	50 46.7%
Group 2 Rank 4-10	60 35.9%	23 38.3%	37 61.7%

Percent of grouped cases correctly classified = 56.3

C. Ammunition Supply

Actual Group		Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1 Rank 1-3	114 68.7%	59 51.8%	55 48.2%
Group 2 Rank 4-10	52 31.3%	20 38.5%	32 61.5%

Percent of grouped cases correctly classified = 54.8

- Judgmental measures of medical support and evacuation show a very weak, perhaps trivial, association with combat effectiveness.

HISTORICAL VARIABLES

Some apparently interesting simple linear associations are identified in Table 1B between historical measures of combat support and combat effectiveness. A few of the equipment availability factors are in the expected direction and strong enough to warrant further examination (landing craft, shore party equipment, ground transport). Small arms ammunition availability shows a reasonable relationship ($r = -.17$) and suggests, in the context of the judgmental ammunition finding) closer examination. Quite large r values show for some shortage variables -- rations (.30), medical supplies (.39), POL (.54), spare parts (.59), and supply delivery (.74).

The detailed matrices for historical variables are presented in Table 3. The landing craft and shore party equipment finding is in the expected direction, but the number of cases involved is simply too small to warrant any logical or statistical conclusion. There are enough cases of assault vehicles used, but only a few were influenced by a shortage and they show no particular trend. Ground transportation shows a small trend away from the expected direction (not nearly significant) -- cases of reduced availability have a higher rate of effective performance.

- Equipment availability has been a problem for friendly forces in so few cases considered in this study that thorough analysis is impossible. The available evidence, however, shows no linkage between equipment availability and combat effective performance.

The next set of variables considered relate to the availability of ammunition (Tables 3E-3I). Lack of small arms and machine gun ammunition were seldom problems and were apparently unrelated to combat effectiveness.

TABLE 3

Association of Combat Support Variables With Combat Effectiveness

A. Equipment Availability: Landing Craft

		Reduced	As Authorized	
Mean Outcome Scores	1-2.79	1	5	6
	2.80 +	2	3	5
		3	8	11

Too few cases for meaningful statistical summary

B. Equipment Availability: Shore Party Equipment

		Reduced	As Authorized	
Mean Outcome Scores	1-2.79	1	4	5
	2.80 +	2	3	5
		3	7	10

Too few cases for meaningful statistical summary

C. Equipment Availability: Assault Vehicles

		Reduced	As Authorized	
Mean Outcome Scores	1-2.79	3	12	15
	2.80 +	2	12	14
		5	24	29

Chi-square = .08 1 degree of freedom s = .76

D. Equipment Availability: Ground Transport

		Reduced	As Authorized	
Mean Outcome Scores	1-2.79	9	10	19
	2.80 +	6	10	16
		15	20	35

Chi-square = .06 1 degree of freedom s = .81

E. Ammunition Availability: Small Arms

		Reduced	Available	
Mean Outcome Scores	1-2.79	2	16	18
	2.80 +	2	15	17
		4	31	35

Chi-square = .17 1 degree of freedom s = .68

Continued

Table 3
Combat Support Variables
Continued

F. Ammunition Availability: Machine Gun

		Reduced	Available	
Mean Outcome Scores	1-2.79	3	16	19
	2.80 +	2	15	17
		5	31	36

Chi-square = .02 1 degree of freedom s = .89

G. Ammunition Availability: Artillery

		Reduced	Available	
Mean Outcome Scores	1-2.79	7	9	16
	2.80 +	5	9	14
		12	18	30

Chi-square = .08 1 degree of freedom s = .78

H. Ammunition Availability: Mortar

		Reduced	Available	
Mean Outcome Scores	1-2.79	7	13	20
	2.80 +	2	14	16
		9	27	36

Chi-square = 1.4 1 degree of freedom s = .25

I. Ammunition Availability: Rocket

		Reduced	Available	
Mean Outcome Scores	1-2.79	0	12	12
	2.80 +	3	12	15
		3	24	27

Too few cases for meaningful statistical summary

Continued

Table 3
Combat Support Variables
Continued

J. Medical Supplies

		Interrupted	Sufficient	Ample	
Mean Outcome Scores	1-2.79	4	13	1	18
	2.80 +	2	8	8	18
		6	21	9	36

Chi-square = 7.3 2 degrees of freedom s = .03

K. Petroleum, Oil, and Lubricant Supplies

		Interrupted	Sufficient	Ample	
Mean Outcome Scores	1-2.79	3	14	0	17
	2.80 +	1	5	6	12
		4	19		29

Chi-square = 10.7 2 degrees of freedom s = .001
Small case base makes statistical summary uncertain.

L. Spare Parts

		Marginal	Interrupted	Sufficient	Ample	
Mean Outcome Scores	1-2.79	2	4	11	0	17
	2.80 +	1	1	5	5	12
		3	5	16	5	29

Too few cases for meaningful statistical summary.

M. Supply Delivery

		Daily	Periodic	Erratic	
Mean Outcome Scores	1-2.79	8	4	6	18
	2.80 +	8	2	6	16
		16	6	12	34

Chi-square = .55 2 degrees of freedom s = .76

Continued

Table 3
Combat Support Variables
Continued

N.1. Delivery Problems: General

		Slight	Some	
Mean Outcome Scores	1-2.79	8	13	21
	2.80 +	10	10	20
		18	23	41

N.1.2. Delivery Problems: Specific

		None	Lack of Transportation	Inadequate Air Delivery	Weather Interruption	Road Interdiction	Equipment Problem	Other	
Mean Outcome Scores	1-2.79	4	4	1	3	3	2	0	21
	2.80 +	10	1	2	1	4	0	2	20
		14	5	3	4	7	2	2	41

Too few cases for meaningful statistical summary.

O. Means of Medical Evacuation

		Foot	Vehicle	Helicopter	
Mean Outcome Scores	1-2.79	9	7	4	20
	2.80 +	4	6	8	18
		13	13	12	38

Chi-square = 5.3 2 degrees of freedom s = .15

P. Speed of Medical Evacuation

		Minutes	Up to 1 hr.	Hours	Days	
Mean Outcome Scores	1-2.79	10	5	3	0	18
	2.80 +	4	10	4	1	19
		14	15	7	1	37

Chi-square = 5.4 3 degrees of freedom s = .15

Artillery and mortar ammunition supply were more often problems, but show a nonsignificant tendency to go in the unexpected direction -- units with shortages of these types of ammunition did somewhat better than units with ample supplies. Interestingly, the three cases with shortages of rocket ammunition were all poor effectiveness cases.

- Ammunition availability has been a problem in relatively few of the cases studied here. The available evidence, however, shows no linkage between ammunition supply problems and combat effective performance.

The pattern for medical supplies, POL, and spare parts is directly opposite to that predicted. In all three cases, units experiencing supply problems performed better than units with ample supplies. Indeed, no difference really exists between units with supply problems and those with sufficient medical supplies, POL, and spare parts. Those with plentiful supplies perform poorly as frequently as those experiencing shortages, leading to the conclusions that:

- Ample supplies of medicine, spare parts and POL do not increase the probability of effective combat performance.

- Units operating with heavy logistics trains show a tendency to perform less effectively than those with smaller supply elements.

This second finding is an interpretation and is based largely on the differences between sufficient and "ample" supplies. It should be clearly understood, however, that the units under study are infantry battalions and do not, in themselves, have extensive logistics capabilities.

The next two Tables (3M and 3N) examine supply delivery problems. Overall delivery frequency shows no particular trend or association with combat effectiveness. There is a small tendency for units with supply delivery problems to perform more effectively than those with few

(Table 3N.1), but it does not approach significance. The most common supply problem encountered was road interdiction (seven cases) with lack of transportation (five), weather interruptions (four), and inadequate air delivery (three) also being worthy of notice. None of these specific cases show a strong association with combat effective performance.

- Historical measures of supply delivery are not systematically associated with combat effective performance.

The last two variables examined in detail were the means of medical evacuation and the speed of evacuation. They appear to produce somewhat contradictory trends. Evacuation by foot is associated with effective performance, by helicopter with relatively ineffective combat performance, and by vehicle with neither. The trend is almost strong enough to be significant.

By contrast, the faster the evacuation of wounded individuals, the greater the probability of effective combat performance. This trend also approaches significance. Speed of evacuation refers to the time period before an individual is removed from the battlefield, not the period between being hit and arriving at a medical facility. It would seem logical that in battles that are going relatively well, the situation will permit prompt movement of wounded to the rear. Even so, the linkage between these two factors and unit effectiveness is not completely clear. The first finding may be related to the absence of helicopter evacuation in World War II engagements, but as no significant difference exists between the effectiveness values assigned to combat eras (see Chapter 2), this seems unlikely.

- There is a tendency (nonsignificant) for units relying on foot evacuation to perform more effectively than those with helicopter support available.

- There is a tendency (nonsignificant) for units that can receive immediate medical evacuation to be

engaged in more effective combat than units that must wait extended periods.

This set of findings may also be linked to the large support tail argument introduced earlier. Prompt evacuation is probably associated with somewhat higher morale and the ability to dominate the battlefield.

CHAPTER 10. THE COMBAT ENVIRONMENT

INTRODUCTION

One important issue not previously addressed is the situation within which an engagement takes place -- the combat environment. Three principal components can be discerned -- the mission that is assigned to the unit, the physical conditions on the battlefield (weather and terrain), and political constraints on unit actions. This last category -- political environment -- was added to the research after discussions of the Phase I results with a number of Marine Corps officers, including the project technical monitor.

In this case, as in the case of coder bias, the research team is searching the available evidence for factors that, while not part of the combat processes themselves, influence the probability of effective combat performance. These factors can then be identified as control variables -- factors that have to the accounted for statistically when other associations with combat effectiveness are measured. Moreover, bias toward a single type of case can constrain the meaningfulness of the research result.

LINEAR RELATIONSHIPS

Table 1 reports the simple linear correlations between combat environment variables and the combat effectiveness measures. No strong associations appear in the table. The lone judgmental variable -- weather -- explains only 1 percent of the variance in combat effectiveness and is assigned a small mean importance value (2.4) by the officer coders. The historical variables show little linear association, for type of engagement, terrain, length of engagement, time of day, weather factors, and a variety of political factors.

TABLE 1

Pearson Product-moment Correlation of Combat Effectiveness With Combat Environment Variables

A. Judgmental Variable

ID#	Variable	r	r^2	n	s	Mean Importance
C48	Weather	-.11	.01	286	.05	2.4

B. Historical Variables

H6	Duration of engagement	.01
H53	Type of engagement	-.03
H179	Primary terrain type	-.08
H182	Time of day	-.00
H183	Weather	.13
H184	Temperature	.00
H195	National attitude	-.08
H199	Restriction on nuclear weapons	.05
H200	Restriction on weapons, non-nuclear	-.05
H201	National boundary restrictions	.06
H202	DMZ fire restrictions	.03
H203	DMZ entry restrictions	.13
H204	Restricted target areas	-.03
H205	Restricted extent of fire	.00
H206	Require political coordination	.07
H207	Require assisted country coordination	.17

NONPOLITICAL VARIABLES

The apparent absence of association between combat environment factors and combat effectiveness was investigated in detail. The nonpolitical variables are reported in Table 2. No clear sources of bias emerge. The duration of engagement (Table 2A) shows a small tendency for poor performance in short engagements, but it does not approach statistical significance.

Type of friendly force engagements offers a direct way to examine missions. Some 22 different amphibious assaults (including ship to shore and shore to shore experiences in World War II, Korea, Lebanon, the Dominican Republic, and Vietnam) constitute the largest share. Day ground attacks (six) and heliborne assaults (five) are the next largest. Two night attacks and two search and destroy missions were included in the study and one prepared defense and three hasty defenses were also included. None of these types show strong bias toward high or low combat effectiveness.

The apparent dominance of amphibious assaults is illusory. While a number of the engagements began as amphibious assaults or included them, the duration of the engagements examined make that a relatively minor portion of the combat in many cases. The primary form of combat experienced by friendly forces is reported in Table 2C. Only six cases are coded as amphibious assaults. Day attacks account for the largest category -- 20 cases -- which reflects the desired offensive focus of the analysis. Five primarily defensive cases; three combat patrols; two movements to contact, night attacks and heliborne assaults; and one tank-infantry action round out the set. The goal of increased variety within a primarily offensive focus was achieved. No category shows a statistical strength of association with combat effectiveness large enough to influence the research results.

TABLE 2

Association of Combat Environment
Variables With Combat Effectiveness

A. Duration of Engagement

Mean Outcome Scores	0-2 days	3-7 days	8+ days	
1-2.79	1	13	7	21
2.80 +	3	9	9	20
	4	22	15	41

Chi-square = 1.8 2 degrees of freedom s = .41

B. Type of Engagement

Mean Outcome Scores	Amphib-*ious* Assault	Heli-*copter* Assault	Ground Attack Day	Ground Attack Night	Search and Destroy	Prepared Defense	Hasty Defense	
1-2.79	11	2	3	2	0	1	2	21
2.80 +	11	3	3	0	2	0	1	20
	22	5	6	2	2	1	3	41

Too few cases per cell for meaningful statistical summary.

continued

Table 2
Combat Environment
Variables
Continued

C. Primary Type of Combat (Friendly)

		Movement to Contact	Attack	Night Attack	Amphibious Assault	Helicopter Assault	Tank-Infantry	Combat Patrol	Defense	
Mean Outcome Scores	1-2.79	1	10	2	4	0	0	1	3	21
	2.80 +	1	10	0	2	2	1	2	2	20
		2	20	2	6	2	1	3	5	41

Too few cases per cell for meaningful statistical summary.

D. Primary Type of Combat (Enemy)

		None	Movement to Contact	Attack	Night Attack	Combat Patrol	Defensive	Retrograde	Sniping	
Mean Outcome Scores	1-2.79	0	0	0	5	0	14	2	0	21
	2.80 +	1	1	1	2	1	13	0	1	20
		1	1	1	7	1	27	2	1	41

Too few cases per cell for meaningful statistical summary.

continued

Table 2
Combat Environment
Variables
Continued

E. Predominant Terrain (Two types per engagement)

Mean Outcome Scores		Open	Jungle	Urban	Sandy Beach	Rocky Shore	Hilly	Moun-tains	Other	
	1-2.79	2	3	3	5	3	12	5	3	36
	2.80 +	4	5	5	3	0	10	3	3	33
		6	8	8	8	3	22	8	6	69

Too few cases per cell to permit statistical summarization.

F. Time of Day

Mean Outcome Scores		Day Only	Both	Night Only	
	1-2.79	4	17	0	21
	2.80 +	7	11	1	19
		11	28	1	40

Chi-square = 3.0 2 degrees of freedom s = .22

G. Weather

Mean Outcome Scores		No Problems	Mud	Rain	Snow	Other Problems	
	1-2.79	17	1	3	0	0	21
	2.80 +	17	1	0	1	1	20
		34	1	3	1	1	41

Too few cases per cell to permit statistical summarization.

Enemy combat is predominately defensive (27 cases). Seven night attacks are the only other large set of cases (Table 2D). The Lebanese landing, which was unopposed, was rated as no enemy combat, the Dominican Republic as sniping only. Two enemy retograde operations were included and one each movement to contact, attack, and combat patrol. There is a tendency for effective friendly combat performance when repulsing enemy night attacks, but it is not large enough (3 cases in 41) to affect the overall balance of effectiveness cases.

The types of terrain involved in the engagements were examined in detail. Table 2E reports both the primary and, where significant, a secondary type of terrain over which the engagements were fought. Seven specific types were found, as well as an "other" category. Hilly terrain, with 22 cases, was the most common. Jungle, urban, sandy beaches, and mountains were each cited eight times. Open and other were coded six times, rocky shore on three cases. Only rocky shore, with three combat effective performances and no ineffective cases, shows a clear trend, and the size of the category is too small to bias the data set.

There was only one engagement where combat was confined to night. Eleven cases of pure day operations were present and 28 cases of both day and night. There is some tendency to do better in day only combat, but the trend fails to be significant.

Finally, Table 2G shows the effect of historical weather variables. Thirty-four cases involved no weather problems: two mud, three rain, one snow, and one "other weather problems" (cold and wind). No strong associations are present, but it is clear that poor weather cases are underrepresented in the data set.

- None of the mission or situational variables show significant statistical association with the combat effectiveness measures. Hence, no statistical controls for combat environment are necessary when evaluating causal relations.

POLITICAL ENVIRONMENT

In response to considerable interest in the subject, the research team added a number of political variables to the data set in Phase II. These variables were coded for all 41 cases by defining the political attitudes and restrictions in force at the time of each battle. Strictly speaking, it is very difficult to expect clear patterns of association between these political variables -- attitudes and policies at the national level -- and the local situation on the battlefield. The causal linkages are so indirect as to make them suspect.

Table 3 reports the associations found. The national attitude was measured indirectly over time by indicators such as popular opinion polls, election results, and congressional speeches. Four categories were coded -- demand the end of war, considerable antagonism, diminished popular support, and strong popular support. While the number of cases calls the significance measure into question, a clear association does exist. Reduced popular support shows a .28 probability of effective performance (4 ÷ 14), while strong popular support shows a .63 probability of effective activity.

- Strong popular support is associated with a higher probability of effective combat performance. However, the causal linkage is so indirect as to be questionable and the small number of cases in some cells makes the association statistically questionable.

The second political variable examined was the explicit renuniciation of the use of nuclear weapons. Many of the "no" cases were drawn from the World War II period and reflect unavailability. Nevertheless, no significant relationship is found between these restrictions and combat effectiveness.

Restrictions on the use of nonnuclear weapons applied in only five cases and no statistically interesting relationships emerges when it is

TABLE 3

Association of Political Environment Variables With Combat Effectiveness

A. National Attitude

		Demand End of War	Considerable Antagonism	Diminished Popular Support	Strong Popular Support	
Mean Outcome Scores	1-2.79	3	1	0	17	21
	2.80 +	1	4	5	10	20
		4	5	5	27	41

Chi-square = 9.6 3 degrees of freedom s = .02

B. Explicit Renunciation of Use of Nuclear Weapons (or unavailability)

		No	Yes	
Mean Outcome Scores	1-2.79	9	12	21
	2.80 +	6	14	20
		15	26	41

Chi-square = 0.3 1 degree of freedom s = .60

C. Restriction on Use of Nonnuclear Weapons

		No	Yes	
Mean Outcome Scores	1-2.79	19	2	21
	2.80 +	17	3	20
		36	5	41

Too few cases per cell for meaningful statistical summary

D. National Boundary Restrictions

		No	Yes	
Mean Outcome Scores	1-2.79	13	8	21
	2.80 +	10	10	20
		23	18	41

Chi-square = 0.2 1 degree of freedom s = .65

Continued

Table 3
Political Environment
Variables
Continued

E. DMZ Fire Restrictions

		No	Yes	
Mean Outcome Scores	1-2.79	19	2	21
	2.80 +	16	4	20
		35	6	41

Chi-square = .26 1 degree of freedom s = .61

F. DMZ Entry Restrictions

		No	Yes	
Mean Outcome Scores	1-2.79	18	3	21
	2.80 +	13	7	20
		31	10	41

Chi-square = 1.4 1 degree of freedom s = .24

G. Restricted Target Areas

		No	Yes	
Mean Outcome Scores	1-2.79	15	6	21
	2.80 +	15	5	20
		30	11	41

Chi-square = .001 1 degree of freedom s = .92

H. Restrictions on Extent of Fire

		No	Yes	
Mean Outcome Scores	1-2.79	21	0	21
	2.80 +	18	2	20
		39	2	41

Distribution of cases precludes statistical summary.

I. Political Coordination Required

		No	Yes	
Mean Outcome Scores	1-2.79	20	1	21
	2.80 +	16	4	20
		36	5	41

Chi-square = 1.0 1 degree of freedom s = .31

Continued

Table 3
Political Environment
Variables
Continued

J. Require Assisted Country Coor'ination

		No	Yes	
Mean Outcome Scores	1-2.79	17	4	21
	2.80 +	11	9	20
		18	13	41

Chi-square = 2.1   1 degree of freedom   s = .15

analyzed. National boundary restrictions, relevant in some 18 cases, show a small tendency to reduce combat effectiveness, but it does not even approach statistical significance.

Two types of demilitarized zone restrictions -- entry restrictions and fire restrictions -- were analyzed. Both seem to show a trend toward diminished effectiveness, but neither trend is statistically significant. The probability of effective combat performance in the absence of DMZ restrictions on fire is .54. In their presence, it is .33. Similarly, entry restrictions have approximately .30 probability of effective performance, while the absence of entry restrictions shows a .58 probability. The numbers of cases, however, are small enough to prevent statistical significance.

- Restrictions involving access and fire into demilitarized zones show a moderate, but statistically nonsignificant, tendency to be associated with lower combat effectiveness.

Other types of restrictions do not show this same impact. Restricted target areas show no trend at all and the presence of only two cases where explicit restrictions existed on the extent of fire prevents statistical association.

Requirement for political coordination (Table 31) suggest an association, but even with only five cases in the restricted set, statistical significance is not achieved. There are more cases (13) in which the requirement for coordination with a host country is considered. In the absence of these restrictions the probability of effective performance is about .61, however when they are present, the probability falls to .31. Statistical significance is not, however, achieved.

- There is a tendency for local political and coordination variables to be associated with decreased combat effective performance. This tendency is not, however, statistically significant.

Given the weakness of the logical link between these political variables and actions on the field, it is most surprising that any trends at all are identified. Contrasted with the fact that enemy activities and a variety of nonpolitical environmental variables intervene, (all of which factors are directly related to the specific engagements), the finding that the political environment is related to outcome seems suspect and should not be granted too much credence.

CHAPTER 11. INTEGRATED ANALYSIS OF COMBAT EFFECTIVENESS

INTRODUCTION

Chapter 3 (Unit Composition and Training) though Chapter 10 (Combat Environment), focused on specific sets of variables related to functional areas and activities. This chapter pulls these activities together and attempts to:

- Compile the crucial factors identified from the historical data set and integrate them into a picture of the activities that an infantry battalion must concentrate on to be effective in a hostile environment,
- Compile the crucial factors identified from the analysis of the judgmental data set and compose a similar list of crucial activities, and
- Compare these two data sets, and produce insights into the overall set of activities units must execute to perform effectively.

HISTORICAL VARIABLES

Tables 1 through 4 summarize the findings from early chapters. Rather than repeat the discussions, arguments, and interpretations from those chapters, the category of each variable has been listed so interested readers can locate the appropriate chapter and review the detailed information in full context. Variables have been divided into four types:

- Those demonstrating clear, linear relationships with combat effectiveness,
- Those demonstrating curvilinear relationships with combat effectiveness,

TABLE 1

Historical Variables That Show Clear, Linear Association With Combat Effectiveness

Category	Variable	Relationship
Unit Composition and Training	Commitment for the Duration	Chi-square = 3.1 s = .08
	Indefinite Overseas Tours	Chi-square = 3.1 s = .08
Preparatory Fires	Fighter Aircraft	None/Poor = .32 chance of good effectiveness; Good/Excellent show .69 chance
	Duration of Preparatory Fires	None-24 hours = .48 chance of good effectiveness; 24 hours + = .72 chance.
Supporting Fires	Intensity of Tank Fires	The presence of friendly armor on the battlefield is associated with a .65 chance of effectiveness; the absence with a .22 chance of effectiveness.
	Intensity of Naval Gunfire	Moderate or high intensity naval gunfire increases the chance of effectiveness from above .38 to about .77.
Enemy Strength and Capabilities	Intensity: Enemy Artillery Number of Batteries, Enemy Artillery -Direct Support -General Support -Total Available Extent of Artillery Opposition	The intensity of fire and strength of enemy artillery forces has a positive association with friendly combat effectiveness at the $r^2 = .06$ level with marginally significant chi-square values.
Combat Environment	National Attitude	Strong popular support is associated with effective performance, dimunition of support with low effectiveness. Chi-square = 9.6 s = .02

TABLE 2

Historical Variables That Show Clear,
Curvilinear Relationships With Combat Effectiveness

Category	Variable	Relationship
Unit Composition and Training	Regimental Training	No training associated with effectiveness; some with no success.
Preparatory Fires	Softening up by Bomber Aircraft	Absence or poor associated with poor effectiveness; good with high effectiveness; excellent with poor effectiveness.
	Artillery: Softening up	None associated with poor effectiveness; poor/fair/good with effectiveness; excellent with poor effectiveness.
	Softening Fires: Overall	None/poor/fair associated with poor effectiveness; good with excellent effectiveness; excellent with poor effectiveness.
Supporting Fires	Close Air Support	None/slight associated with poor effectiveness; moderate is associated with good effectiveness; intense is associated with poor performance.
Combat Support	Medicine Spare Parts POL	Units rated as having ample medical, spare parts, and POL stocks perform less effectively than units having shortages or merely adequate supplies.

TABLE 3

Historical Variables That Show Relatively
Weak Relationships With Combat Effectiveness

Category	Variable	Relationship
Unit Composition and Training	Accelerated Training	Slight tendency for accelerated training to associate with high effectiveness.
	Level with Primary Planning Responsibility	Regiment shows weak association with poor performance; division with high effectiveness.
Unit Actions During the Engagement	Intensity of Fire from Organic Crew Served Weapons	Chi-square = 2.9 s = .23 None/moderate = .33 chance of good effectiveness; heavy = .59
Supporting Fires	Intensity of Artillery	Artillery is intense, particularly in heavy combat, but shows no power to improve effectiveness when considered alone.
	Overall Intensity of Supporting Fires	A statistically nonsignificant tendency exists for intensity of support fires to be associated with combat effectiveness.
Enemy Strength and Capabilities	Availability of Armor, Effectiveness of Tank Fires, and Severity of Armor Opposition	Statistically nonsignificant tendency for enemy armor to be associated with better friendly combat effectiveness.
	Enemy Command and Control	Statistically nonsignificant tendency for better enemy command and control to be associated with worse friendly effectiveness.

Continued

Table 3
Historical Variables
Continued

Category	Variable	Relationship
Combat Support	Equipment Availability	Landing unit and assault vehicles show small, nonsignificant association with combat effectiveness.
	Delivery Problems	Small, nonsignificant tendency for units with supply delivery problems to perform more effectively.
	Medical Evacuation: Type	Units evacuating by foot are most effective; by vehicle less; by helicopter least. Chi-square = 5.3 s = .15.
	Medical Evacuation: Speed	Units evacuating more rapidly are more effective, Chi-square = 5.4, s = .15.
Combat Environment	Time of Day	Daylight fighting appears somewhat more effective than night or mixed.
	National Boundary Restrictions	A small tendency for less effective performance when restrictions exist.
	DMZ Fire Restrictions DMZ Enemy Restrictions	A small tendency for restrictions on DMZ entry and fire to be associated with poor performance.
	Political Coordination Country Assisted Coordination	A small tendency for coordination to be associated with poor performance.

TABLE 4

Historical Variables That Show No Association With Combat Effectiveness

Category	Variable	
Unit Training	Time of the Battalion Commander with the unit	
	Average time of key officers with the unit	
	Months in the combat theater	
	Previous operations	
	Previous operations of the type	
	Battalion training	
	Division level training	
	Field maneuvers	
	Rehearsals for the operation	
	Unit strength	
	Months in combat	
	Type of friendly troops	
	Time available for planning	
Preparatory Fires	*Immediate preparations* by:	Fighter aircraft
		Bomber aircraft
		Artillery
		Naval gunfire
Battalion During the Engagement	Effectiveness of fire from organic, crew served weapons	
	Strength of linkage -- Company Commander to platoons	
	Strength of linkage -- Battalion Commander to Company Commanders	
Supporting Fire	Effectiveness of fires:	Artillery
		Close air support
		Naval gunfire
		Tank fires
		Overall
	Number of artillery batteries:	Total
		Direct support
		General support

Continued

Table 4
Historical Variables
Continued

Category	Variable	
Enemy Strength and Capabilities	Type of enemy troops	
	Preparation of positions	
	Extent of opposition	
	Intensity of fire:	Crew served weapons
		Naval gunfire
		Close air support
		Overall
	Effectiveness:	Crew served weapons
		Close air support
		Overall
	Severity of opposition:	Infantry
		Air
	Availability:	Air artillery
		Mortars
		Naval gunfire
		Antiair
Combat Support	Ground transportation	
	Weapons supply	
	Assault vehicles	
	Ammunition availability	
	Small arms	
	Artillery ammunition	
	Mortar	
Combat Environment	Duration of Engagement	
	Type of Engagement:	Friendly viewpoint
		Enemy viewpoint
	Primary form of combat	
	Primary type of terrain	
	Weather	
	Restrictions on the use of nuclear weapons	
	Restrictions on the use of nonnuclear weapons	
	Restricted target area	

- Those demonstrating relatively weak relationships with combat effectiveness (regardless of whether it is linear or curvilinear), and

- Those for which no evidence of a relationship was found in the analysis.

The reader should understand that the appearance of a variable in Table 4 -- Historical Variables That Show No Association with Combat Effectiveness, does not imply that the variable is never important in combat. Rather, the correct understanding is that:

- The analyses carried out in this research did not show a systematic relationship between the variable and the combat effectiveness measures, and

- There are at least three reasons why factors that are important determinants of combat effectiveness might not demonstrate association in this research effort.

  - The factor might be represented too few times in the 41 cases examined,

  - The factor might be very important but only in a few cases, hence not <u>generally</u> important, or

  - The factor may have been measured poorly because of lack of historical information or an inadequate coding procedure.

Hence the research team wants to stress the fact that this type of empirical research is best utilized for finding positive relationships -- associations between causal factors and a dependent variable. The statistical and logical procedures utilized are intentionally conservative -- they will not support a false association, but they run the risk of ignoring some true ones.

A related comment should be made with respect to variables classified in Table 3 -- Historical Variables That Show Relatively Weak Relationships With Combat Effectiveness. Imperfections of data and measurement, or

more commonly, the presence of only a few cases in which the factor had an impact, may well have led the research team to classify an association as weak when it does have influence on the battlefield. However,

- The conservative nature of research is the only protection available against false conclusions, and

- The purpose of this research program is to increase our understanding of combat effectiveness <u>and</u> identify the high leverage items that can be manipulated to increase combat effectiveness across a wide variety of situations.

Hence, relatively weak associations have not been ignored, nor do they warrant extensive discussion at this point in the report. Many of the weak relationships contributed to an understanding of the processes being observed. For example, the identification of a modern technology battlefield as a positive contribution to effective performance by U.S. Marine Corps infantry battalions was suggested by the peculiar impact of enemy artillery on the battlefield, but confirmed by the weaker relationship of enemy armor with combat effectiveness. These detailed, and often problematic, discussions have been left in the specific activity chapters where they belong.

The interesting analyses are those of factors found to be clearly associated with combat effectiveness. These are reported in Table 1 (Linear Relationships) and Table 2 (Curvilinear Relationships). Some 21 individual variables were found to be important.

- Three from unit training and composition,
- Five from preparatory fires,
- Three from supporting fires,
- Six from enemy strength and capabilities,
- Three from combat support, and
- One from combat environment.

Interestingly, no planning activities or actions of the battalion during combat were found to have direct, clear relationships with combat effectiveness on the basis of the historical data. These factors, which include much of the role of the commander, are difficult to measure historically. Only two historical planning variables were collected and only four of those collected for the "battalion actions during the engagement" produced enough data to support analysis. The research team noted that:

- Historical data relating to planning, actions of the battalion during an engagement, and, particularly, the role of the commander, are extremely difficult to collect and measure.

Hence, the absence of these factors from the historical findings list was not really surprising. Judgmental factors were available to prevent a gap in knowledge about these combat processes.

An integrated analysis and ranking of the factors demonstrated important by historical research is presented in Table 5. The analysis is integrated in that no effort has been made to stay at the individual variable level -- where sets of activities are best understood by combining individual variables into concepts this has been done. The set is ranked in that a relative power of the relationship between the factor and combat effective performance has been assessed. This is a judgmental process, not a mathematical one. The evidence supporting the judgment is summarized under the heading "influence". The research team had to assess the relative predictive power of a number of very different types of association -- changes in the probability of combat effective performance, curvilinear relationships based on relatively low frequencies, tests of significance, and the patterns of association themselves.

Based on these judgments, the presence of friendly armor is the single most important historical fact determining the likelihood of combat effectiveness. A variety of reasons can be offered, including

TABLE 5

Historical Factors Influencing
Combat Effectiveness: Summary

Rank	Factor	Influence
1	Presence of friendly armor during the engagement	Increases probability of combat effectiveness by about .43, but present in only a few battles.
2	Intense naval gunfire during the engagement	Increases probability of combat effectiveness by about .39, but present in only a few battles.
3	Preparatory air: Fighters (softening up phase)	Increases probability of combat effectiveness by about .36.
4	Preparatory fires lasting more than 24 hours	Increases probability of combat effectiveness by about .24.
5	Artillery support during the engagement	Presence poor, fair, good enhances probability of combat effectiveness except in most intense combat.
6.5	Close air support during the engagement	Both of these variables show good effectiveness with good performance, poor effectiveness with none or slight and fail to help in the most intense combat.
6.5	Preparatory air: Bombers (softening up phase)	
8	Strength of support at home undiminished	Statistically significant association with effective performance (long causal link) (s = .02).
9	Troops obligated for the duration and staying overseas indefinitely	Marginal statistical association with effective performance (s = .08).
10	Modern technology battlefield	Enemy strength in artillery and armor increases probability of friendly combat effectiveness at the margin.
11	Adequate, but minimal logistics tail	Units with ample supplies of medicine, spare parts, and POL perform less effectively than those with sufficiency or supply problems.

positive impact on friendly morale, negative impact on enemy morale, shock effect, enhanced fire power, and the relatively modern battlefield implied by tanks (see rank 10). However, the limit on this finding is that it is based on a relatively small number of battles with friendly armor present.

The variable ranked second, intense friendly naval gunfire during the engagement, is also not universally available. When present, however, it has a relatively dramatic impact on the effectiveness of friendly forces.

The use of fighters and fighter/bombers during a softening up phase for an operation also shows a clear tendency to enhance the probability of combat effectiveness. Here, too, shock and negative enemy morale as well as the highly visible assistance to friendly forces probably add to the physical damage done to enemy forces and positions.

Softening up generally also shows a positive impact on friendly forces if it continues for at least 24 hours. This, of course, may not be tactically wise or logistically possible in all cases. However, shorter softening up phases do not show a systematic positive impact on the probability of effective performance.

The fifth ranking factor was artillery support during the engagement. This was in stark contrast to the preliminary data analyzed in Phase I (largely judgmental) where artillery was found to be almost unrelated to combat effectiveness. With the larger data set, however, it is clear that the absence of artillery support lowers the probability of effective performance. Moreover poor, fair, and good artillery support are all associated with good combat effectiveness. However, intense artillery fire is associated with poor combat effectiveness apparently because the most intense fire occurs when the situation is at its worst. Artillery fire, in itself, does not improve these situations.

Two variables tied for next most important -- Close Air Support During the Engagement and Softening Up Through the Use of Bomber Aircraft. Intense close air support and intense softening up by bombers are both associated with poor combat performance. As with artillery support, these activities are increased in desperate situations but do not, in themselves, turn them around. Both of these variables show good combat effectiveness with good intensity values. They are weaker than artillery, however, because both their absence and poor performance associate with poor combat effectiveness while even poor artillery intensity associates with good combat effectiveness ratings.

One of the political environments variables added in the Phase II analyses ranks eighth -- strength of support for the war at home. Despite the long and very tenuous causal chain between national attitude and occurrences on the battlefield within the sector of a single battalion, a statistically significant association is present. This factor can also be explained in part as a combat era effect, but is not purely so because some engagements from Korea are included in the low support group.

A somewhat weaker, but more directly linked association was found between the type of obligation that the political system levies on the individual soldier and combat effective performance. Troops obligated for the duration and staying overseas indefinitely have a higher probability of combat effectiveness than other troops. This factor is also somewhat associated with combat era and must be understood in that context.

The presence of a relatively modern battlefield as evidenced by heavy enemy artillery activity and the presence of enemy armor is also associated with combat effective performance by U.S. Marine Corps infantry battalions. This is only a moderately strong relationship and is "constructed" from the analysis rather than measured directly, but it

makes sense in that United States military forces are designed, equipped, and trained for modern combat rather than fighting irregular forces.

The final important finding based on historical variables is another construction from evidence. Because of an observed tendency for units with "ample" supplies of medicine, spare parts, and POL to perform less effectively than units rated as having "sufficient" supplies or supply problems, the inference was drawn that the presence of a minimal logistics "tail" can be associated with combat effective performance at the battalion level. Two caveats must be understood.

- This may well be a case where what is good for the battalion may not be good for larger organizations -- logistics support may be better handled elsewhere, and
- The size of the "tail" was not directly measured in the research performed.

Overall, historical variables seem to link combat effective performance with:

- The presence of specialized forces (armor and naval gunfire) to provide overwhelming local fire and force superiority on a local basis,
- Intense, extended preparatory fires, particularly from the air, where tactically feasible,
- Intense supporting fires during the engagement, particularly where the tactical situation is not desperate,
- Attention to political considerations providing popular support for war efforts,
- Obligating troops for the duration of the conflict and keeping them overseas indefinitely,
- Maintaining a minimal logistics tail at the tactical level, and

- Modern battlefield conditions rather than those in which the enemy lacks indirect fire weapons or armor.

JUDGMENTAL VARIABLES

One of the important differences between this research project and others is the systematic use of two types of variable sources:

- Historical variables that can be coded more or less directly from archives, and
- Judgmental codings elicited from a variety of officers to provide insight into the more intangible aspects of combat.

"Systematic analysis" is emphasized to ensure that readers not assume that this research examines only what officers say are important determinants of combat effectiveness. The crucial research question is rather:

- How much of what officer coders indicate they believe to be the determinants of combat effective performance is associated with an independently derived measure of combat effectiveness.

Hence, the judgmental codings are constrained in two important ways -- first, they are constrained by the context of historical engagement descriptions; and second, they are constrained by association with combat effectiveness.

The first constraint was built into the data collection process. Officers were not asked to select the critical factors influencing combat effectiveness in the abstract. Rather, each officer coder was given one or more narrative descriptions of engagements to read. He was asked, after completing each of the narratives, to identify which of the set of critical factors influenced the combat effectiveness of

the friendly battalion in the engagement itself. The narrative was designed to provide evidence and clues that would activate memories and thoughts from the officer coders' experience. They were intended as well to focus attention on real world concerns and specific issues rather than abstract doctrine.

The officer codings were additionally filtered by the use of analytical techniques that compare them with measures of combat effectiveness. A variable such as "Quality of Information" (selected as important a large number of times by officer coders), was compared with the relative combat effectiveness of units rated to have performed well in terms of the quality of information functions. In this case, only weak association was found between the codings of the variable and the combat effectiveness measure. This can happen because:

- The variable is coded as important and the unit as performing well on it in most cases, but the combat effectiveness of the unit varies from case to case,
- The variable is coded as unimportant or the unit is performing badly on it in most cases, but the combat effectiveness of the unit varies from case to case, or
- Both the coding of unit performance on the variable and the combat effectiveness of the unit vary from case to case, but their variation is not systematically associated.

Hence, this second filter (strength of association) was used to test officer judgment about the importance of critical factors on the battlefield.

Simple Correlation Analyses

The most basic technique utilized to measure the strength of association between judgmental variables and combat effectiveness was a simple bivariate correlation. These statistics compare the change in

two variables on a case by case basis and range between -1.0 and +1.0. Values near zero mean the absence of association, values near 1.0 mean that the two variables vary together (when one is high the other is high); and when the value approaches -1.0 the variables form a mirror image (when one is high the other is low). The key statistics are Pearson product-moment correlations (r) and approximate percentage of variance explained (r^2).

The correlation of the most interesting judgmental variables with the combat effectiveness measure are presented in Table 6, ordered by amount of association (highest r^2) with combat effectiveness. All the variables were coded as "critical factors" in determining combat effectiveness more than 100 times. All except two (medical support and air preparation) showed statistically significant association with combat effectiveness. This significance is, however, often due more to the relatively large number of officer codings available than the percentage of variation associated with combat effectiveness.

The specific interpretation of the findings in the different functional areas has been presented in earlier chapters and will not be repeated here. Rather, attention is focused on the pattern of variables when ranked by association with combat effectiveness.

The top two variables -- implementation of the principles of war and overall unit effectiveness -- are tautological, appeared in the data set largely as cross checks on the coding methodology and anchors for the interpretation of complex analyses, and provide no actionable information for building more effective units.

The three specific variables that show strongest association with combat effectiveness -- resourcefulness during the engagement, planning for the use of subordinate units, and maneuver (r^2 = .21 and .22) -- are quite interesting. All three relate to the commander, one is a

TABLE 6

Comparative Association With Variance in Combat Effectiveness Based on Correlation

ID#	Variable	n	r	r^2	s
C54	Implementation: Principles of war	195	-.55	.27	.001
C52	Overall unit effectiveness	282	-.52	.27	.001
C110	Resourcefulness	245	-.47	.22	.001
C40	Plan: Subordinate units	264	-.47	.22	.001
C74	Maneuver	258	-.46	.21	.001
C94	Security on the move	127	-.44	.19	.001
C100	Reaction to the unexpected	278	-.44	.19	.001
C108	Initiative	261	-.40	.16	.001
C76	Use of fire	227	-.39	.15	.001
C106	Aggressiveness	270	-.38	.15	.001
C104	Discipline	170	-.38	.14	.001
C12	Plan: Quality	281	-.36	.13	.001
C6	Training	258	-.35	.12	.001
C128	Communications	182	-.32	.10	.001
C42	Awareness of enemy	264	-.32	.10	.001
C34	Timeliness of order	232	-.32	.10	.001
C36	Plan: Use of reserves	236	-.31	.10	.001
C92	Position preparation	118	-.30	.09	.001
C112	Casualties: Impact	239	-.30	.09	.001
C90	Night positions	200	-.29	.09	.001
C84	Close air support	181	-.29	.09	.001
C98	External linkages	214	-.28	.08	.001
C38	Plan: Logistics	199	-.24	.06	.001
C8	Morale (prior)	190	-.24	.06	.001
C72	Artillery support	214	-.23	.06	.001
C116	Ammunition supply	166	-.23	.05	.001
C102	Morale (during)	165	-.21	.04	.003
C10	Quality of information	273	-.20	.04	.001
C80	Naval gunfire	117	-.16	.03	.040
C96	Armor support	142	-.14	.02	.046
Significance Cutoff					
C114	Medical support	167	-.11	.01	.078
C82	Air preparation	153	-.05	.00	.277

planning variable, and all three relate to the adaptive behavior concept.

This interpretation is strengthened when the next two variables (r^2 = .19) are examined -- security on the move and reaction to the unexpected. Both are command related and take place within the battalion itself.

The top 10 are rounded out by initiative, use of fire, and aggressiveness, which have the same attributes. Indeed, the first variable explicitly dealing with activities outside the unit (communications) ranks fourteenth.

This pattern dominates the analysis. Supporting fires, intelligence, communications, and logistics are consistently ranked low and show relatively little association with combat effectiveness. Command functions and activities that take place within the unit are ranked relatively high and show nontrivial association with combat effectiveness. This contrasts starkly with the historical variable findings that effective fires were an important element in determining combat effectiveness.

Discriminant Functional Analyses

In an effort to better understand the data on judgmental variables, many of the same variables were subjected to a different analytic technique -- discriminant function analysis. As reviewed earlier, this technique operates on a somewhat different logic than correlation. With discriminant function analysis of a bivariate (two variable) relationship, the key question is how well the independent variable (in this case a judgmentally derived critical factor) will correctly predict the placement of a case on a dependent variable (combat effectiveness). For this research, the combat effectiveness scores were divided into two groups, effective performance (rank 1-3) and poor performance (rank 4-10).

Table 7 shows a list of judgmental critical factors rank ordered on the basis of predictive ability. The number of cases included in the analysis, the chi-square statistic for the analyses, and the resulting level of significance are also noted. Virtually all of the variables are significantly associated with combat effectiveness, again because of the rather large number of officer codings available. Some predict combat effectiveness quite well.

The rank order here takes the same general form as that found with correlation techniques. The two overall measures of unit performance score as the best predictors of combat effectiveness, correctly placing more than three quarters of the cases.

All of the top ten variables project between 64 and 69 percent of the cases correctly. Close air support (ranked seventh) is the only factor in the top 10 significantly involved with activities outside the unit. The bottom 10 is largely composed of outside factors, however they appear much more often in the middle part of the list as well. The size of the gap between unit actions and support activities is also smaller in these analyses than the correlation analyses.

The role of the commander is heavily represented in the highest ranking group, as are variables associated with adaptive behavior (reaction to the unexpected), and with unit movement while in contact. Training shows up well and planning functions are well represented.

Comparing Correlational and Discriminant Rankings

Correlational analysis and discriminant functional analysis are two statistically different procedures for examining the same type of relationship. They were both applied in order to increase analytic valid ty. Since they showed different patterns, their results were composed and integrated (Table 8). The calculation differences are not, themselves,

TABLE 7

Comparative Discriminant Power of
Judgmental Combat Effectiveness Predictors

ID#	Variable	n	Percent of Cases Correctly Placed	Chi-square	s
C54	Implementation: Principles of war	194	76.4	56.1	.001
C52	Overall unit effectiveness	282	75.1	71.5	.001
C100	Reaction to the unexpected	278	68.4	48.2	.001
C6	Training	258	67.8	32.5	.001
C40	Plan: Subordinate units	205	67.3	42.1	.001
C12	Plan: Quality	281	66.2	36.2	.001
C84	Close air support	178	65.8	12.2	.001
C64	Maneuver	264	65.5	50.3	.001
C34	Timeliness of orders	231	65.1	26.1	.001
C76	Use of fire	226	64.3	22.9	.001
C94	Security on the move	127	63.0	32.4	.001
C38	Plan: Logistics	198	62.3	13.1	.001
C78	Artillery support	216	61.7	8.9	.003
C98	External linkages	213	61.2	15.2	.001
C106	Aggressiveness	268	60.7	38.6	.001
C8	Morale (prior)	188	60.5	5.5	.019
C108	Initiative	260	60.5	41.0	.001
C36	Plan: Use of reserves	235	60.2	14.2	.001
C128	Communications	182	59.9	12.5	.001
C110	Resourcefulness	244	59.2	46.0	.001
C90	Night positions	196	59.0	10.8	.001
C42	Awareness of enemy	264	58.0	30.5	.001
C114	Medical support	164	56.3	3.8	.051
C10	Quality of information	273	55.7	11.8	.001
C116	Ammunition supply	164	54.8	7.5	.006
Significance Cutoff					
C80	Naval gunfire	111	53.9	2.1	.114
C82	Air preparation	149	53.6	0.8	.358
C96	Armor support	141	52.1	0.4	.521

TABLE 8

Integrated Ranking of Judgmental Critical Factors: Correlation Versus Discriminant Power

Variable	Average Rank	Difference	Rank on Correlation	Rank on Discriminant Power
Plan: Subordinate units	2.5	1	2	3
Reaction to the unexpected	3.0	5	5	1
Maneuver	4.5	3	3	6
Training	6.0	8	10	2
Security on the move	6.5	5	4	9
Plan: Quality	6.5	5	9	4
Use of fire	7.5	1	7	8
Resourcefulness	9.5	17	1	18
Timeliness of orders	10.0	6	13	7
Aggressiveness	10.5	5	8	13
Initiative	10.5	9	6	15
Close air support	10.5	11	16	5
Communications	14.0	6	11	17
Plan: Logistics	14.0	8	18	10
External linkages	14.5	5	17	12
Plan: Use of reserves	15.0	2	14	16
Artillery support	15.5	9	20	11
Awareness of enemy	16.0	8	12	20
Morale (prior)	16.5	5	19	14
Quality of information	22.0	0	22	22
Ammunition supply	22.0	2	21	23
Medical support	23.0	4	25	21
Naval gunfire	23.5	1	23	24
Armor support	25.0	2	24	26
Air preparation	25.5	1	26	25

important here, but an understanding of their influence on the summary statistic is important if the composition is to be meaningful. Basically, a Pearson product-moment correlation is more sensitive to outlying data points than discriminant function analyses. Hence, a variable with a strong correlation relationship and a relatively weaker discriminant relationship probably contains a set of cases with values at the extreme end of a scale. The discriminant function technique will weigh this type of case less heavily and find a relatively weaker relationship. The opposite occurs when the data for the variable are "bimodal" -- distributed in two clusters. Here the discriminant function technique discovers and emphasizes the existence of the clusters themselves while the correlation technique detects them as scatter on the dependent variable and summarizes the variable as weaker. For "good" variables with normal distributions about their own means, the two techniques will have little disagreement.

Returning to Table 8, it is possible to examine the integrated rank orders and the basis for their calculation. A mean rank was computed based on the 26 meaningful variables available from both correlation and discriminant analysis. (General variables like overall effectiveness have been dropped). The "difference" column refers to the absolute differences between the rank orders on the two types of analysis. Hence, a variable with a small difference is one where the two techniques are in agreement about the importance of the judgmental critical factor and a large difference implies considerable disagreement.

The consensus leader is planning for the use of subordinate units, ranked third by discriminant function analysis and second by correlation. Reaction to the unexpected, maneuver, training, and security on the move round out the top five. The persistence of the command dominated pattern with adaptive behavior, training, and movement shows the perception of the coding officers that the unit controls its own fate.

At the bottom of the scale are six variables, all heavily related to activities beyond the unit boundaries, that the two techniques indicate are not important when combat effectiveness is determined. Included in them are armor support and air preparation, both in the important influence category when historical variables were analyzed. Close air support, ranked 12th, is the highest of any of the outside variables.

- Judgmental rankings of critical determinants of combat effectiveness emphasize command related functions and unit activities and deemphasize the impact of activities outside the battalion.

Of the original groups of functions under analysis, the top half of the list contains:

- Nine activities of the battalion during the engagement,
- Two planning activities,
- One variable from unit composition and training, and
- One supporting fire variable.

In terms of the "constructed activities" that have emerged as important in the analyses, the breakdown would be:

- Five measures of command quality,
- Two measures of plan quality,
- Two measures related to unit movement,
- One measure of quality of unit training,
- One measure of the use of fire,
- One supporting fire, and
- One communications measure.

At least five of these variables relate to adaptive behavior -- the process of learning about the battlefield and adjusting to the situation there.

- Reaction to the unexpected,
- Maneuver,
- Timeliness of orders,
- Initiative, and
- Communication.

Equally important, the bottom half of the set (communications in 13th place is included in both the top and bottom) consists of:

- Four command support variables,
- Two supporting fires,
- Three planning functions,
- Two actions by the battalion during the engagement,
- One preparatory fires variable, and
- One unit composition and training variable.

Examining the size of difference measures, the two techniques show considerable disagreement about resourcefulness, close air support, initiative, logistics planning, training, artillery support, and awareness of the enemy. Resourcefulness and initiative, quite direct measures of adaptive behavior, do much worse on the discriminant function technique than on the correlation technique. Hence, their "predictive power" must be based on a subset of cases that are not typical of the rest of the data set. The study of units experiencing severe shock and surprise (Chapter 13) confirms this and indicates that the shock and surprise cases are those that provide the power for the resourcefulness variable.

Awareness of the enemy also does better on correlation calculations and must be showing extra power based on a set of outlying cases.

Close air support, logistics planning, artillery support, and training have the opposite pattern. They are better predictors of combat effectiveness when discriminant function techniques are utilized. Hence, they have "bimodal" distributions in which two natural clusters have formed and can be consistently projected. Units either do well on them or relatively poorly but there are few cases in between the two groups.

- Resourcefulness, initiative, and awareness of the enemy are important determinants of combat effectiveness in only a limited number of situations, but, when they are important, they have a relatively powerful influence.
- Close air support, logistics planning, artillery support, and training are judged as either relatively good or relatively poor, but there are few units rated between these clusters.

FACTOR ANALYSIS

The relative importance of judgmental critical factors cannot, however, be assessed in isolation. A glance at Table 6, where the r^2 column represents the total percentage of variation in the judgmental critical factors, shows that far more than 100 percent of the variance is apparently accounted for by the independent variables. Moreover, analyses of the sets of judgmental variables in different functional areas has already shown that the variables themselves are not independent -- units that do some of the planning activities well also do others well, battalion actions during the engagement are associated with one another. This is the "multicolinearity" problem discussed in Chapter 4.

Equally important, the research team needed an understanding of the <u>structure</u> of the judgmental variable set. This structure provides

insight into the collective thinking of the officer coders -- it helps to explain what types of variables they view as related and which types they view as relatively independent.

The correct technique for this type of analysis is factor analysis, the same technique utilized in Chapter 2 to determine the dimensionality of the combat effectiveness measures. In this case, however, the issue is the identification of meaningful dimensions in the judgmental critical factors data so as to understand them better and provide a basis for data reduction. Factor analysis can enhance comprehension of a data set because it identifies redundancies -- the natural clusters of variables that allow construction of insightful arguments and meaningful composite concepts. It will enhance data reduction because it makes it possible to use "marker variables" from each cluster rather than the full set. Moreover, with orthoganal rotation, factor analysis produces relatively unrelated clusters so that subsequent analysis using marker variables is less subject to multicolinearity.

A five factor solution was found, using the 29 variables best suited for the technique, that was both statistically sound and theoretically appealing. Table 9 reports the data on this solution. The eigenvalues and percentage of variance show the relative strength or power of each factor in the solution. The factor loadings opposite each variable indicate the approximate correlation between the variable and the vector that describes the factor. The communality indicates the extent to which the factor analysis "explains" the variance in each named variable. To help the reader, squares have been placed around the highest factor loading for each variable, regardless of the absolute number. Circles have been placed around all values greater than or equal to 0.30. These two symbols are employed for all values that have relatively important associations with any factor.

TABLE 9

Varimax Rotated Factor Matrix
For 28 Crucial Factors

Variable	Factor I	Factor II	Factor III	Factor IV	Factor V	Communality
Initiative	.83	.08	.14	.12	-.01	.76
Resourcefulness	.82	.20	.18	.25	.10	.81
Aggressiveness	.76	.15	.17	.04	.10	.64
Discipline	.61	.17	.13	.14	.21	.48
Reaction to the Unexpected	.71	37	.15	.14	.15	.67
Use of Fire	.55	43	.18	.18	-.00	.56
Armor Support	40	.54	-.02	.18	.00	.48
Close Air Support	38	.64	.13	.05	.01	.75
Artillery	30	.65	.25	.06	.04	.58
Communications	.23	.61	.25	.19	.17	.56
External Linkages	.18	.72	.24	.07	.24	.67
Ammunition Supply	.11	.77	-.01	30	.20	.73
Plan: Logistics	.01	.69	.27	.11	.23	.62
Naval Gunfire	33	.66	41	.04	-.19	.75
Position Preparation	35	.19	.11	.80	.09	.82
Night Positions	.17	.25	30	.72	-.01	.70
Impact: Casualties	.49	.29	.12	34	.15	.47
Maneuver	.50	.18	42	41	.18	.67
Implementation of Principles of War	.51	.22	41	33	.24	.64
Plan: Subordinate Units	.44	.15	33	.20	.28	.44
Secure Movement	46	.08	.47	47	.10	.67
Plan: Principles	41	.25	.58	.29	.08	.66
Plan: Quality	34	.25	.68	.18	.24	.73
Quality of Information	.02	.23	.68	.06	.14	.54
Awareness of Enemy	.21	.12	.64	.23	.18	.55
Plan: Use of Reserves	.15	.20	.52	.05	33	.45
Training	.17	.03	35	.14	.61	.56
Timeliness of Orders	.10	30	40	-.12	.66	.71
Morale (Before)	.27	.28	.13	.23	.36	.36
Eigenvalues	12.28	1.94	1.82	1.10	0.71	
Percentage of Variance	68.7	10.9	10.2	6.2	4.0	
Suggested Interpretation	Command Functions	Support and Linkages	Planning and Intelligence	Tactical Execution	Unit Preparation	

Naming (Interpreting) the Factors

One of the most difficult and crucial elements in factor analysis is deciding what the factors mean. Of course, any factor is a statistical artifact and means nothing in the real world. Frequently, factor analysis solutions are found that appear to be based on spurious correlations -- no apparent logic can theoretically link statistically associated elements. But when a factor is found to suggest association between theoretically meaningful variable clusters, great care must be taken to name or "label" the factor clearly to prevent misinterpretation later when the statistical artifact is forgotten and the research concepts are being utilized. This is particularly difficult when a large number of different variables are being summarized in a few factors.

Factor I has been named "Command Functions." Its strongest set of factor loadings are with relatively intangible aspects of leadership and decision-making -- initiative, resourcefulness, unit aggressiveness, discipline, and reaction to the unexpected. All these variables intercorrelate fairly highly with one another (see Chapter 6), and the set includes the "adaptive behavior" measures. They are almost independent of other factors, but show some relatively weak association with Factor II. Very interestingly, use of fire is not far away, and Factor I also is marginally stronger than other factors for the impact of casualties on performance (a leadership variable), maneuver, implementation of the principles of war, and planning for the use of subordinate units. These variables, however, show mixed loadings -- relationships with Factors III and IV as well as with I. Security on the move, a badly divided variable, has nearly its highest loading on Factor I, and nontrivial associations exist for two planning variables (plan consistency with the principles of war and plan quality) and four supporting fires variables (armor, close air support, naval gunfire, and artillery). Position preparation, a tactical concept but also a measure of the control exercised by the unit leadership in that tired soldiers do not instinctively improve positions unless

discipline and leadership are strong, is also related to the factor at a nontrivial level. Factor I is by far the strongest found, accounting for the bulk of the common variance in the set and having the largest eigenvalue by far.

The second natural dimension in the data, Factor II, has been named Support and Linkages. Its strongest loadings are with the external linkages and ammunition supply variables. Logistics planning is nearly as strong. All the supporting fires cluster here -- naval gunfire, artillery, close air support, and armor. A barely nontrivial timeliness of orders component is also associated. These support functions clearly form a set in the minds of the coding officers. The center of the set is communications and logistics, both of which are relatively independent of other factors.

The fire support variables show linkages to the Command factor and probably account for the presences of nontrivial associations with use of fire and reaction to the unexpected. The Support and Linkages Factor is almost completely independent of Factors III, IV, and V.

Planning and Intelligence, Factor III, corresponds very well with the planning phase variables. The strongest loadings are plan quality and quality of information available to the unit. Planning for the use of reserves, awareness of the enemy, and security on the move all have their highest loadings on this variable. An interesting linkage of S-2 and S-3 functions is thus posited by the officer coders. Nontrival associations abound -- maneuver and implementation of the principles of war are marginally related concepts.

Planning and Intelligence is perhaps the "messiest" of the factors, having clear association with Command Functions, Factor IV, and Factor V.

Factor IV has been called Tactical Execution because its only two highest loaders, preparation of positions and adequacy of night positions, are

perhaps the most detailed variables available in the judgment set. It also picks up associations with security on the move (.47) and maneuver (.41), both tactical dimensions. Ammunition supply and implementation of the principles of war are marginally related concepts.

The last factor includes both of the judgmental variables from the unit composition and training set (morale before the action and unit training) along with timeliness of orders (a result of unit training and standard operating procedures). Its only minor loading is planning for the use of reserves. It was named Unit Preparation to indicate the fact that it seems to tap readiness activities rather than actions by the battalion in the hostile environment.

COMPARISON OF FACTOR STRUCTURE WITH PHASE I RESEARCH

The findings from Phase II appeared as this point to be sufficiently different from those of the Phase I pilot effort that a decision was made to compare them. Phase I research focused on a relatively few variables and cases in order to determine the utility of the research methodology. Only 13 judgmental critical factors were utilized in the factor analysis for that data set. The results of that analysis are presented in Table 10 and a parallel analysis (the same 13 variables for data including both the Phase I and II data sets) is reported in Table 11.

The purpose of this analysis is to compare the factor structure of the data sets -- to see whether different variables will form natural clusters in them. Simple inspection makes it clear that they do, indeed, form very different clusters. The Phase I factors, labeled Coordination Functions, Planning Functions, and Supporting Fires showed a pattern of much greater complexity than the Phase II data set. In Phase II, for example, the intelligence functions dominate Factor III and have nontrivial associations with quality of plan and logistic support. In Phase I they are part of a coordination set and show several other close

TABLE 10

Factor Analysis of Phase I
Judgmental Critical Factors Variables

Short Title	Factor I	Factor II	Factor III	Communality	n
	Factor Loadings				
Quality of Information	.89	38	.06	.93	44
Quality of Plan	54	.69	.11	.78	47
Logistics Support	.48	33	.20	.38	36
Awareness of Enemy Capabilities	.74	34	.20	.70	42
Implementation of Principles of War	31	.75	.22	.71	36
Maneuver During Action	33	.61	.24	.54	46
Artillery Support	.58	.15	31	.45	34
Naval Gunfire	.26	.65	54	.78	21
Preparatory Air Interdiction	.25	.85	.27	.87	16
Close Air Support	.18	.22	.96	.99	17
Armor Support	-.22	31	.76	.72	42
Linkages to External Units or Commands	.48	32	38	.47	42
Communications	47	.15	.70	.74	38
Eigenvalues	6.46	1.82	.79		
Percentage of Variance	71.20	20.00	8.70		
Suggested Interpretation	Coordination Functions	Planning Functions	Supporting Fires		

TABLE 11

Factor Analyses of Phase II
Judgmental Critical Factors Variables

Short Title	Factor I	Factor II	Factor III	Communality
	Factor Loadings			
Quality of Information	.23	.13	.82	.74
Quality of Plan	31	.58	49	.67
Logistics Support	.62	.11	33	.50
Awareness of Enemy Capabilities	.14	39	.63	.57
Implementation of the Principles of War	30	.79	.17	.74
Maneuver	.29	.77	.22	.72
Artillery Support	.66	.29	.17	.55
Naval Gunfire	.77	.25	.23	.70
Preparatory Air Interdiction	.58	.18	.27	.44
Close Air Support	.70	.22	.12	.55
Armor Support	.62	.29	-.15	.50
External Linkages	.74	.16	.20	.61
Communication	.67	.20	.20	.53
Eigenvalues	5.95	1.15	0.72	
Percentage of Variance	76.0	14.8	9.2	
Suggested Interpretation	External Support	Command	Intelligence	

associations. The biggest difference, however, is the cluster of supporting fires, communications, and logistics on Factor I of Phase II. These are well spread in Phase I.

In short, the enhanced variation in the coder population, the increased complexity of engagement types considered, and the inclusion of severe shock and surprise variables in the data set clearly worked to alter the structure of the judgmental critical factors data set.

FACTOR ANALYSIS INCLUDING COMBAT EFFECTIVENESS

While the five factor structure reported in Table 9 is interesting, it does not provide any good information on the relationship of the judgmental variable clusters with combat effectiveness. Hence, the analysis was rerun with the combat effectiveness measure included in the set. This has two results. First, the presence of new variables in the data set can change the factor structure -- there can be more or fewer clusters or variables may be related to different clusters. Second, the factor loading of the combat effectiveness measure on each factor is a measure of its association with combat effectiveness.

The results of this new factor analysis are reported in Table 12. There are some changes in factor structure as a result of the addition of the combat effectiveness measure.

First, a new factor was created (Factor VI). It had a nontrivial association with only one variable -- naval gunfire. That variable was more closely associated with Factor II. Moreover, the sign indicating the relationship between Factor VI and combat effectiveness is positive, indicating a wrong direction. Hence, the factor was viewed as a statistical artifact (due, in fact, to a single case with rather unusual events in it) and not considered in the substantive analysis of the factor analysis solution.

TABLE 12

Varimax Rotated Factor Matrix
For 28 Crucial Factors With Combat Effectiveness

Variable	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI	Communality
Resourcefulness	.84	.22	.20	.23	-.01	-.06	.84
Initiative	.82	.17	.11	.18	.07	.15	.76
Aggressiveness	.74	.14	.17	.05	.18	.14	.65
Discipline	.59	.14	.16	.13	41	.13	.60
Reaction to the Unexpected	.75	40	.20	.10	-.04	-.11	.78
Use of Fire	.55	42	.14	.19	.07	.14	.56
Armor Support	38	.53	-.05	.18	.13	.15	.50
Close Air Support	37	.61	.10	.06	.13	.19	.58
Naval Gunfire	30	.64	.27	.11	-.07	49	.82
Artillery	.28	.63	.22	.08	.10	.21	.58
Ammunition Supply	.11	.77	.06	.27	.17	.13	.73
Communications	.25	.63	30	.18	-.01	-.07	.59
External Linkages	.20	.76	33	.04	-.02	-.13	.74
Plan: Logistics	.02	.69	33	.11	.11	.02	.61
Night Positions	.17	.24	.24	.75	.08	.10	.72
Position Preparation	34	.20	.11	.79	.15	-.03	.82
Casualty Impact	.49	32	.16	31	.03	-.12	.49
Secure Movement	.48	.10	48	48	-.15	-.05	.73
Maneuver	.53	.21	45	41	-.02	-.07	.69
Implement: Principles of War	.52	.21	45	32	.19	.02	.66
Plan: Subordinate Units	.46	.16	42	.18	.10	-.11	.46
Plan: Principles of War	40	.24	.54	33	.06	.20	.66
Plan: Quality	33	.25	.70	.20	.07	.13	.72
Plan: Use of Reserves	.17	.23	.63	.03	-.01	-.11	.49
Quality of Information	.02	.21	.66	.10	.02	.22	.55
Awareness of Enemy	.20	.10	.64	.27	.08	.15	.56
Training	.17	.06	.55	.10	38	-.22	.54
Timeliness of Orders	.09	31	.61	-.16	40	-.16	.70
Morale (Before)	.23	.27	.23	.23	.49	.02	.54
Combat Effectiveness	-.43	-.09	-.33	-.14	-.12	.19	.37
Eigenvalues	12.58	2.00	1.86	1.13	0.76	0.62	
Percentage of Variance	66.4	10.6	9.8	5.9	4.0	3.3	
Suggested Interpretation	Command Functions	Support and Linkages	Planning and Intelligence	Tactical Execution	Unit Cohesion	Statistical Artifact	

Second, the overall shape of the solution did not change radically. Eigenvalues and percentages of variance explained remained almost stable. Moreover, there was no change in communality (from a mean of .640 to a mean of .644), excluding the new variable.

The .37 communality value of the combat effectiveness measure indicates that the new variable is not really well represented in the factor analytical solution. Of the six factors, only I and II show nontrival direct association with effectiveness and VI is, as mentioned earlier, clearly a statistical artifact and of no substantive interest.

Although the factor solution is largely unchanged, some interesting shifts occur. The most important of these involves Factor V. In the new solution it has only a single variable with highest loading -- morale before the engagement. Nontrivial association is shown with both unit training and timeliness or orders, previously associated strongly with the factor. Discipline, one of the variables in the command complex, shifts over enough to have a .41 factor loading. As a consequence the factor was relabeled Unit Cohesion, reflecting the impact of both preparation (training, morale) and actions during the engagement (timeliness of orders, discipline).

Factor IV, Tactical Execution, remains essentially unchanged. Night positions and position preparation form the core variables with secure movement being associated almost as strongly with this factor as two others. Nontrivial relationships remain with maneuver, impact of casualties and the two principles of war variables.

Planning Intelligence, Factor III, clarifies its structure and undergoes some fairly substantial changes. Its core variables remain plan quality and quality of information with awareness of enemy, planning for the use of reserves, and planning in accordance with the principles of war showing strong relationships. Hence, the marriage of S-2 and S-3 functions remains largely intact. However, both training and timeliness of

orders shift their largest loading from Factor V to this factor. Secure movement shifts its largest loading marginally away to Factor I, but remains clearly associated with III. New nontrivial associations are discovered with communications and external linkages, and one with naval gunfire disappears. Others remain essentially unchanged, but Planning and Intelligence shows a pattern of association involving all other factors to a relatively great extent.

The Support and Linkages factor remains relatively isolated, with ammunition supply, external linkages, and logistics planning forming its core and all of the supporting fires placing their highest loadings on it. The impact of casualties on unit performance moves up to nontrivial association, but the change in loading required is really very small. The factor is clearly a cluster of activities that officer coders see as requiring unit attention but being beyond the immediate control of the battalion.

The powerful factor, Command, takes on the highest loading for secure movement, but the actual change in loading is quite small. The leadership, adaptive behavior, and movement components of command show themselves to be thoroughly intertwined.

The cluster of variables that appear on Factors I, III, and IV provide an interesting insight. Secure movement, maneuver, implementation of the principles of war, and planning according to the principles of war link together command, execution, planning, and intelligence activities in the minds of the officer coders.

The mixture of support communications and fire support components provides another interesting insight into the viewpoint of officer coders. The actions of the unit are not seen as closely tied to acting in concert with support elements, be they supporting fires or supply components.

Based on these analyses, one would conclude that infantry battalions seeking to improve combat effective performance should examine five component areas:

1. Command, which consists of four intertwined components:
   - Leadership,
   - Adaptive behavior,
   - Movement, and
   - Fire.
2. Support and linkages, which consists of three intertwined components:
   - Supply
   - Communications, and
   - Support fire.
3. Planning and intelligence, which are inextricably intertwined,
4. Tactical execution, and
5. Unit cohesion.

Combining these results (returning to Table 6 for relative power to explain variance in combat effectiveness to get a measure of association) we can construct Table 13. The role of the unit leaders, particularly as evidenced by movement of the unit and adaptive behavior, is the most important element in increasing the probability of combat effectiveness. These activities are influenced most strongly by the battalion commander, but require the assistance of leadership throughout the unit. Explicit leadership traits, probably reflecting the role of the battalion commander himself, and the use of fire on the battlefield are inextricably intertwined with these actions, although not as important as adaptive behavior and unit movement. This command activity appears to be at least twice as important as any other factor in determining combat outcomes.

TABLE 13

Variables Selected on the Basis of Factor Structure
as Explanations of Combat Effectiveness

Factor	Variable	r^2 with Effectiveness	Factor Relative Power
Command			.18
- Leadership	Aggressiveness	.15	
- Adaptive Behavior	Resourcefulness	.22	
- Movement	Maneuver	.21	
- Fire	Use of Fire	.15	
Support and Linkages			.07
- Logistics	Ammunition Supply	.05	
- Communications	External Linkages	.08	
- Support Fires	Close Air Support	.09	
	Artillery	.06	
Planning and Intelligence			.09
- Planning	Plan Quality	.13	
	Plan: Use of Reserves	.10	
- Intelligence	Quality of Information	.04	
	Awareness of the Enemy	.10	
Tactical Execution	Position Preparation	.09	.09
	Night Positions	.09	
Unit Cohesion	Morale	.06	.08
	Discipline	.14	

Planning and intelligence, the S-2/S-3 activities, are the second most important activities altering the probability of combat effectiveness. Planning before the execution phase and including specific assignments to units (subordinate units and reserves) are the features that appear most salient. Intelligence activities, particularly awareness of enemy capabilities, are intertwined here, suggesting that officer coders consider the information component to be an integral part of the planning process.

Nearly equal importance is assigned to the specific elements of tactical execution on the battlefield. The effective implementation of standard operating procedures down to and including preparation of positions is a way of influencing the probability of combat effectiveness.

Only marginally less important is unit cohesion. This factor is related to the command cluster, particulary through leadership activities. However, there is an impact on combat effectiveness from building a cohesive organization with good morale and discipline.

The final cluster of predictors, slightly weaker than any of the others, consists of activities outside the unit -- logistics, communications, and supporting fires. The relatively strong showing of some forms of supporting fires in the historical variable set implies that the two measurement techniques focus on different aspects of the battlefield, not that either one is wrong. Judgmental techniques appear to succeed at capturing the dynamics of command, planning, intelligence, unit cohesion, and tactical execution, all of which are difficult to measure in pure historical data. Historical data measures the observable -- combat support, supporting fires, political climate, and so forth, in detailed ways that judgment cannot match.

Predictive Algorithms (Procedures)

Before leaving judgmental variables, the research team was charged with developing algorithms that can forecast the results of combat based on data about the unit and its relative capabilities to carry specific functions. These integrated analyses also allow examination of the specific interrelationships among clusters of judgmental critical factors as they relate to combat effectiveness.

Multiple regression analysis, which uses correlational logic, was selected as the tool for this analysis. A set of "marker" variables was selected based on the factor analyses and a calculation to project the combat effectiveness measure was undertaken. The results of this regression are shown in Table 14.

Several pieces of information are needed to evaluate a regression equation. The ideal equation has a high "multiple R," which reflects the extent to which the variance in the dependent variable is "explained" by the independent variables, and consequently a high (approaching 1.00) percentage of variance explained (adjusted multiple R^2). It has a relatively small standard error and a large F statistic.

The key to evaluating a regression equation, however, lies in the relationships between each individual independent variable and the dependent variable. These are summarized by B, the standard error of B, and beta. B represents the slope of the regression line selected to represent the relationship between the dependent and independent variables. A large B means that the leverage of the independent variable is great -- a small change in the independent variable is associated with a large change in the dependent variable. The standard error of B is the boundary of confidence around the estimate of B. If the standard error of B is larger than B itself, it is possible that B is estimated in the wrong direction, or does not differ significantly from 0 (has no leverage at all). Beta

refers to a normalized B. Because different variables have different scales, B is not directly comparable across variables. When all independent variables are "normalized" or placed on equivalent scales, leverage can be compared. Hence, beta is the weighting function of a regression analysis. Strong betas are a sign of a "good" regression.

By these criteria, the regression reported in Table 14 is reasonably good. The adjusted multiple R^2 of .29 indicates that four variables can be used to "explain" almost one-third of the variation of combat effectiveness in the data set. The B values are all in the correct direction and while the beta values are fairly small, only close air support shows a real weakness. Close air support also has another problem -- the standard error of the B value is larger than B itself, so the true B could be zero or even on the other side of zero based on the evidence available. This variable contributes little to the statistical explanation.

Substantively speaking, only four variables were utilized because of the desire for parsimony -- the use of a few clear ideas to explain the variation in combat effectiveness. Given the amount of overlap between factors in the structural analysis, some variables were selected because they could represent more than one factor effectively. Command Planning and Intelligence, having shown both the greatest strength and the greatest promise as predictors of combat effectiveness, were allowed to predominate. Unit Cohesion and Support and Linkages were both represented directly. Tactical execution variables were tried, but reduced the explanatory power of the equation (due largely to overlap with other factors) in this context, so they were excluded from the analysis.

Even when choosing on the basis of a factor analysis that was designed to identify independent clusters of variables, the multicolinearity problem was present in the analysis. Table 14B shows the pattern of intercorrelation among the four variables used in the analysis. Every variable intercorrelated with at least two of the other three in a nontrivial

TABLE 14

Regression Analysis Using Selected Variables
From Judgmental Critical Factors to Project Combat Effectiveness

A. Regression

Variable	Factor(s)	B	Standard Error of B	Beta	Bivariate Correlation
Resourcefulness	Command	-.43	.16	-.28	-.47
Plan: Subordinate Units	Command/ Planning and Intelligence	-.33	.14	-.23	-.47
Training	Planning and Intelligence/ Unit Cohesion	-.21	.12	-.15	-.35
Close Air Support	Support and Linkages/ Command	-.05	.15	-.04	-.29

Multiple R = .57

Multiple R^2 = 32

Adjusted Multiple R^2 (approximate percentage of variance explained) = .29

Standard Error = 1.49

F Statistic = 8.39

B. Intercorrelation Matrix

	Variable	C110	C40	C6	C84
C110	Resourcefulness	1.00			
C40	Plan: Subordinate Units	.47	1.00		
C6	Training	.26	.44	1.00	
C84	Close Air Support	.48	.34	.13	1.00

(.30 or higher) manner. One compensation for this effect is the use of adjusted multiple R^2 rather than the multiple R^2 itself. This reduces the chances of assigning false explanatory power to a regression algorithm.

Of course, with the large number of variables being examined, there were literally hundreds of regressions that could be run and reported. A variety of combinations were tried, but only three others will be discussed here:

- Regression designed to maximize explained variation in combat effectiveness,
- Regression using an alternative measure of combat effectiveness, and
- Regression best representing current understanding of combat effectiveness.

Each of these analyses is typical of the sensitivity testing approach by which a research team explores the detailed causal patterns in a large data set.

Table 15 shows a regression designed to maximize explained variation. The Phase I pretest data set (CACI, 1977) showed nearly three-quarters of the variation explained, so the one-third values found in the factor analysis based regression was seen as disappointing. The key to improving explanation proved to be introducing control variables for officer coders (especially military education) and combat era of the engagement. With these two items considered, a set of five variables could be located that produced a multiple R^2 of .75, but the multicolinearity in the independent variables left the percentage of explained variance at about .55. Note that achieving maximum R^2 values means sacrifice of conceptual clarity. The use of the control variables alters the variation to be explained so much that some of the substantive independent variables

TABLE 15

Regression Controlling for Officer Coder and Combat Era
With Critical Factors as Predictors of Combat Effectiveness

Variable	B	Standard Error of B	Beta
Officer Coder	2.29	1.35	.38
Combat Era	1.14	.82	.25
Communications	1.38	.50	.54
Maneuver	-.51	.30	-.37
Artillery Support	-.24	.25	-.19
Plan: Quality	.62	.37	.42
Timeliness of Orders	-.56	.45	-.33

Multiple R = .87

Multiple R^2 = .75

Adjusted Multiple R^2 (approximate percentage of variance explained) = .55

Standard Error = 1.34

F Statistic = 3.82

(plan quality for example) wind up with B values in opposite directions from those expected.

A validity check was also made by changing the value of the dependent variable. Table 16 shows the results of a regression where the "mission accomplishment" definition of combat effectiveness was substituted for the "combat effectiveness in light of all other forces" measure chosen in Chapter 2. Using this alternative measure of combat effectiveness, it is possible to explain 42 percent of the variance with three carefully chosen critical factors -- resourcefulness, training, and logistics planning. Here, the multicolinearity problem has been minimized (see 15B) and therefore only a small difference occurs between the value for multiple R^2 and adjusted multiple R^2.

Finally, Table 17 reports a regression that is typical of our current understanding of projecting combat effectiveness. It uses control for the educational background of the officer coder, and recognizes the role of command, support functions, and planning/intelligence. It shows the ability to project about half of the variance in combat effectiveness.

As is discussed under research needs later, the data and techniques are available to forecast combat effectiveness and identify the characteristics and capabilities of units that have a higher probability of performing effectively. Enough research has been done to prove the concept. Now the system must be built by a thorough and exhaustive set of sensitivity analyses.

INTEGRATED UNDERSTANDING OF COMBAT EFFECTIVENESS: HISTORICAL AND JUDGMENTAL VARIABLES

Based on all these analyses, plus a variety of readings and the experience of the research team, thirteen major items influencing the probability of combat effective performance were distilled from the data.

TABLE 16

Regression of Selected Critical Factors on Alternative
Measures of Combat Effectiveness

A. Regression

Variable	B	Standard Error of B	Beta
Resourcefulness	-.79	.13	-.49
Training	-.38	.11	-.27
Plan: Logistics	-.11	.11	-.08

Multiple R = .66

Multiple R^2 = .44

Adjusted Multiple R^2 (approximate percentage of variance explained) = .42

Standard Error = 1.39

F Statistic = 25.1

B. Pattern of Intercorrelation

	Variable	C110	C6	C38
C110	Resourcefulness	1.00		
C6	Training	.26	1.00	
C38	Plan: Logistics	.27	.28	1.00

TABLE 17

Typical Regression

Variable	B	Standard Error of B	Beta
Officer/Coder	2.48	.52	.36
Implementation: Principles of War	-.76	.17	-.43
Use of Fire	-.49	.19	-.26
Close Air Support	.09	.11	.05
Awareness of Enemy Capabilities	-.15	.11	-.11

Multiple R = .72

Multiple R^2 = .52

Adjusted Multiple R^2 (approximate percentage of variance explained) = .49

Standard Error = 1.40

F Statistic = 18.7

Ten were military functions, and three were conditions under which military engagements take place. The functions (see Table 18) range from the construction of a cohesive unit prior to placing it in a hostile environment to tactical execution on the battlefield.

These lists include factors from both the judgmental analyses and the historical. The approximate weights are judgmental, based largely on the intersections between the two sets of analyses. As such, they may appear overly precise, but a serious attempt was made to keep the multiple values reasonable so that reliance on rank orders would be unnecessary. No argument is implied that the 13 items are independent of one another -- they certainly are not. Moreover, the failure to have an item represented does not mean it cannot or does not influence the probability of combat effectiveness. This list does, however, identify and provide approximate weights for those items that show a general influence on combat effectiveness across the 41 engagements for which analysis has been carried out.

Commanders stand firmly astride the combat effectiveness spectrum. Their role is crucial in two related, but also different ways. They must provide the means for their units to recognize and react to a battlefield situation -- they must make the organization capable of learning and acting on its knowledge. Measures such as resourcefulness, initiative, and reaction to the unexpected show consistent power of explanation. At the same time units must have leadership that provides discipline, aggressiveness, and other attitudinal (rather than decision-making) characteristics down to the individual level. While conceptually clearly distinct, these two elements of command action were thoroughly intertwined in the data analyzed -- one existed without the other only where combat effectiveness was reduced.

Almost as important as command is the creation of local superiority on the battlefield. The means of creating superiority is irrelevant to the

TABLE 18

Factors Influencing Combat Effectiveness

A. Functions

Rank	Factor	Approximate Weight
1	Command - adaptive behavior	.20
2	Command - leadership	.16
3	Creation of local superiority Movement Fire Supporting fires	.15
4	Intense, extended preparatory fires	.13
5	Planning, detailed use of assets	.12
6	Tactical execution	.09
7	Unit cohesion	.08
8	Intelligence	.07
9	Communications	.06
10	Logistics Availability Minimum "Tail"	.05

B. Conditions

Rank	Factor	Approximate Weight
1	Popular support for war	.10
2	Unlimited troop commitment	.07
3	Modern technology battlefield	.05

fact of doing it. Hence, movement, the use of fire, and the use of supporting fires can be utilized independently or in combination, but the fact of the local superiority is the important result.

Moving to a precombat phase, the use of intense, extensive preparatory fire ranks fifth on the generalized list of factors. With the caveat that these fires do not, in themselves, associate with success in difficult combat unless the preparatory fires exceed 24 hours, this can be a powerful influence on combat effectiveness. Note, however, that it shows only a little more than half of the leverage of command functions based on the data analyzed.

Tactical execution -- represented by position preparation, choice of night positions, security on the move, and maneuver shows up as a key component of combat effectiveness, followed closely by intelligence and communications capabilities.

The final element, logistics, is a composite of making critical materials available, logistics planning, and the mimimization of the logistics "tail" of the battalion. Logistics aspects showed a persistent, but never really large, relationship to combat effectiveness. Overall, the evidence seems to suggest that logistics is about one-quarter as important as the command/adaptive behavior concept.

Of the three sets of conditions showing relationships with combat effectiveness, two are political or policy related. In the absence of popular support at home, the probability of combat effective performance must be considered less. Moreover, given limited troop commitments (in the form of limited overseas tours and/or limited enlistment periods), the probability of effectiveness is also lowered. Both of these factors are, of course, somewhat related to historical combat eras and relatively indirectly linked to the performance of a specific battalion at a specific point in time. Hence, this finding must be understood as empirically present, but logically somewhat suspect.

Finally, there was a tendency for U.S. Marine Corps battalions to perform more effectively on a "modern" battlefield where enemy forces were supported by relatively heavy artillery forces and/or some armor. Because the data set is historical, "modern" here means indirect fire weapons and armor on both sides, not extensive counter-air assets, smart weapons, and the like. The finding makes intuitive sense in that U.S. military forces are generally designed, equipped, and trained for a modern battlefield. Moreover, the finding that enemy surprise (Chapter 12) in tactics is the only type of surprise that is likely to reduce the probability of combat effectiveness would be consistent with this explanation. Here, again, combat era may be a confounding factor because of the unique nature of the Vietnam situation.

CHAPTER 12: UNIT EFFECTIVENESS OVER TIME

INTRODUCTION

One of the specialized analyses performed during Phase II was to examine the changes in combat effectiveness that occur as units spend time in a combat theater. The mere experience of the unit (time spent, previous operations, and so forth) was shown in Chapter 3 to have no statistically significant relationship to effective combat performance. This simple measure of change with experience does not, however, deal with the way in which combat itself influences performance. This chapter addresses the question of how performance changes when the period between combat engagements is varied.

CASE SELECTION

To perform the research, cases were needed that showed the same battalion, in the same combat era (or war) at two or more different periods of time. There was an interest in providing a variety of different situations -- different combat eras, different periods of time between eras, different units, and different numbers of cases for the units being studied. Since this topic was selected as a point of emphasis for Phase II research, the choice of new cases for this phase was strongly influenced by these criteria. As Table 1 shows, however, there were three pairs of engagements from Phase I that already met the criteria -- the Third Battalion, 29th Marines during World War II at two different times on Okinawa; the Third Battalion, Fifth Marines in Korea at Inchon and the Yudam-ni Breakout, and the Second Battalion, First Marines in Korea at Yongdungpo and in Seoul.

Phase II case selection included a series of five engagements involving the Second Battalion, Seventh Marines in Vietnam to represent that

TABLE 1

Engagements Involving Units Over Time

ID#	Short Title	Unit	Era	Time Since Previous Engagement
14	Okinawa, Motobu	3/29	WWII	--
15	Okinawa, Oroku	3/29	WWII	7 weeks
23	Bougainville	3/9	WWII	--
24	Guam III	3/9	WWII	35 weeks
25	Iwo Jima I	3/9	WWII	30 weeks
6	Inchon	3/5	Korea	--
20	Yudam-ni Breakout	3/5	Korea	10 weeks
11	Yongdungpo	2/1	Korea	--
18	Seoul I	2/1	Korea	1 week
32	Sudong	1/7	Korea	--
22	JAMESTOWN	1/7	Korea	76 weeks
28	Seoul II	3/1	Korea	--
29	Hagaru Perimeter	3/1	Korea	9 weeks
30	Hwachon Breakthrough	3/1	Korea	20 weeks
31	"BUNKER HILL"	3/1	Korea	62 weeks
35	HARVEST MOON	2/7	Vietnam	--
36	UTAH	2/7	Vietnam	11 weeks
37	ALLEN BROOK	2/7	Vietnam	114 weeks
38	MAMELUKE THRUST	2/7	Vietnam	12 weeks
39	IMPERIAL LAKE	2/7	Vietnam	108 weeks

conflict. A series of four engagements involving Third Battalion, First Marines was chosen for Korea, and a series of three battles with the Third Battalion, Ninth Marines was selected for World War II. A final pair of engagements was created by matching the First Battalion, Seventh Marines at Jamestown from Phase I with the same unit at Sudong.

In all, 20 of the 41 cases were thus involved in the analysis of change of effectiveness over time. Thirteen specific pairs were created for comparison. Five World War II cases were involved, with three change observations. Ten Korean War cases were examined, with a total of six change observations. Five Vietnam cases were chosen with four change observations. Seven different Marine Corps battalions were studied. The range of time between cases ran from 1 to 114 weeks, with six observations in the first 12 weeks and three beyond 60 weeks.

DATA ANALYSIS

While the data set available for analysis constituted a reasonably large portion of the cases examined and showed a good range, it was intended to be large enough to support analysis using powerful multivariate techniques. Straightforward approaches were utilized to ensure that the research team understood the process at work. Accordingly, the first step in the analysis was to calculate and plot the changes observed in the combat effectiveness scores over time. These calculations were simple. The combat effectiveness score of an earlier engagement was subtracted from the combat effectiveness score of a later engagement. The result was a measure of change in effectiveness. The lower the score in combat effectiveness rankings, the more effective the battalion was considered to be. A negative value indicated improved effectiveness, a positive value indicated decreased effectiveness. The range of scores could theoretically have been ten points (the rank scale), but realistically could not exceed about four points because the lowest (best) mean ranking assigned was 1.3, while the highest (worst) was about 5.3.

A good distribution was achieved, with scores ranging from +1.7 to -3.4. There was no obvious effect for combat era -- Vietnam, Korea and World War II all provided both improved and decreased effectiveness cases.

These changes in combat effectiveness were then plotted against the length of time (measured in months) between engagements (Figure 1). An extremely interesting pattern appeared. Improved effectiveness occurs fairly rapidly, at between one and three weeks. The impact is temporary, however, decaying as early as one month after the first engagement and definitely not maintaining its strength over time.

These changes can come from a variety of different sources. Clearly the improved performance on the short run is related to adaptive behavior -- the units are reacting to new information and/or the heightened stimulus of combat. Relatively frequent engagements apparently sharpen the unit and focus its attention on the elements essential to combat effective performance.

Improved effectiveness does not, however, sustain itself over time. The decay in performance over time can come from the change of personnel, the wearing down of will and energy over extended periods, the loss of the "newness" of stimuli from combat, or all these.

Fearful that the small number of data points might be misleading, the research team decided to "normalize" the data. To do this, all the scores are related to the mean and standard deviation of the set. A value that is exactly on the mean has a standardized score of 0. A value that is one standard deviation above the mean has a value of +1.0. This is a standard transformation and is performed before most simple statistical operations such as Pearson product-moment correlation. Its purpose is to reduce skewness in a data set and flatten out the variation about the mean. It was appropriate here because the relatively large change associated with some of the observations could be producing a false pattern of data.

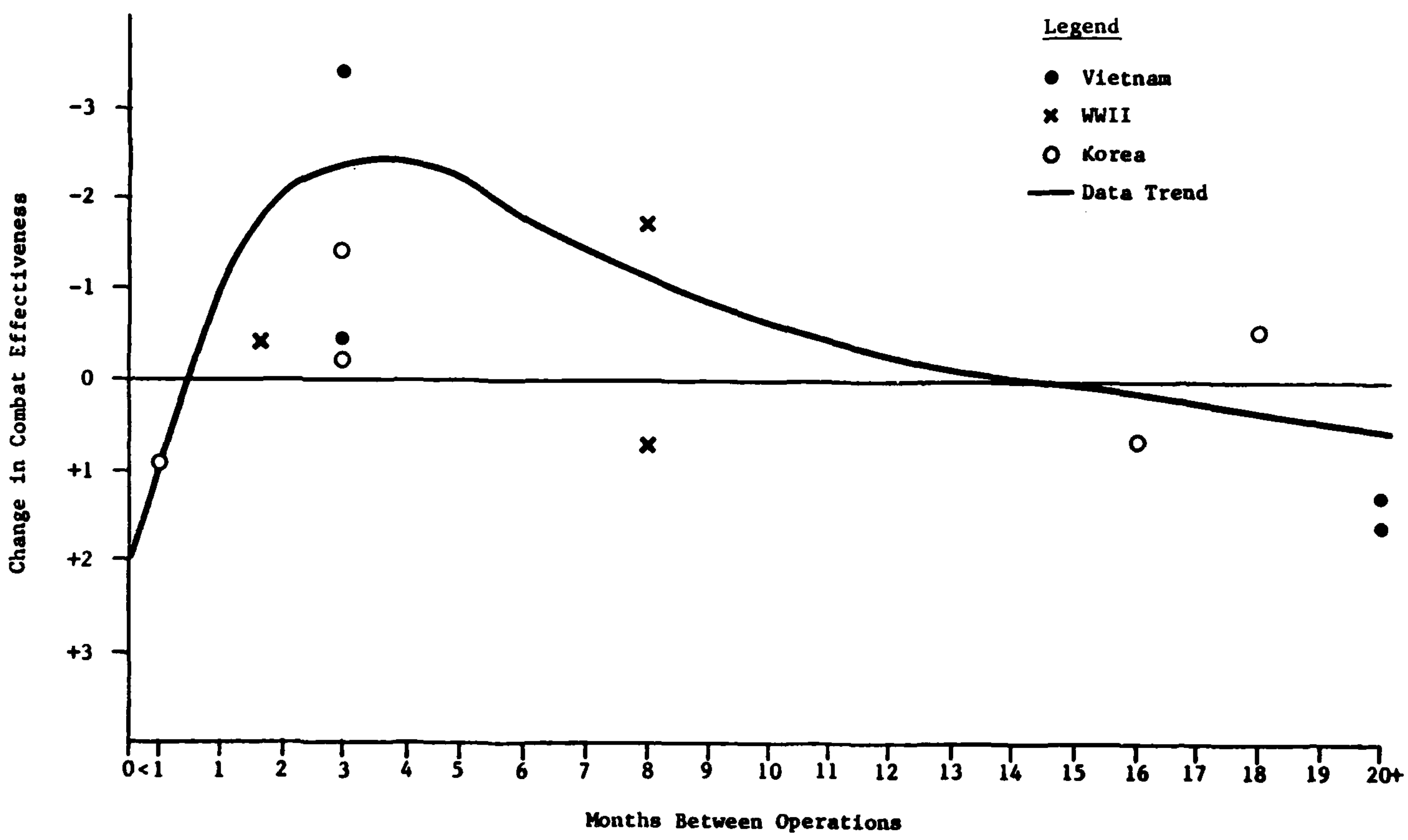


Figure 1. Plot of Raw Data for Change in Unit Combat Effectiveness Over Time

The standardized values for the combat effectiveness measures and the resultant values for change in combat effectiveness are presented in Table 2. The span continues to be fairly great, ranging from -1.5 to plus 0.9. (Minus signs indicate improvement in rating because low rankings are "good" performances). The plot of this data (Figure 2) follows almost exactly the same path at the raw data. Learning appears to occur somewhat more slowly and last longer, but once it begins to decay (about 4 months) the decline is both stronger and more rapid. Using standardized scores, no engagement beyond an 8 month lag shows improved performance -- they all show decreasing effectiveness.

- Units in combat are able to increase combat effectiveness through adaptive behavior (whether due to new knowledge or the increased stimulus environment) over a period of up to tweleve weeks between engagements.

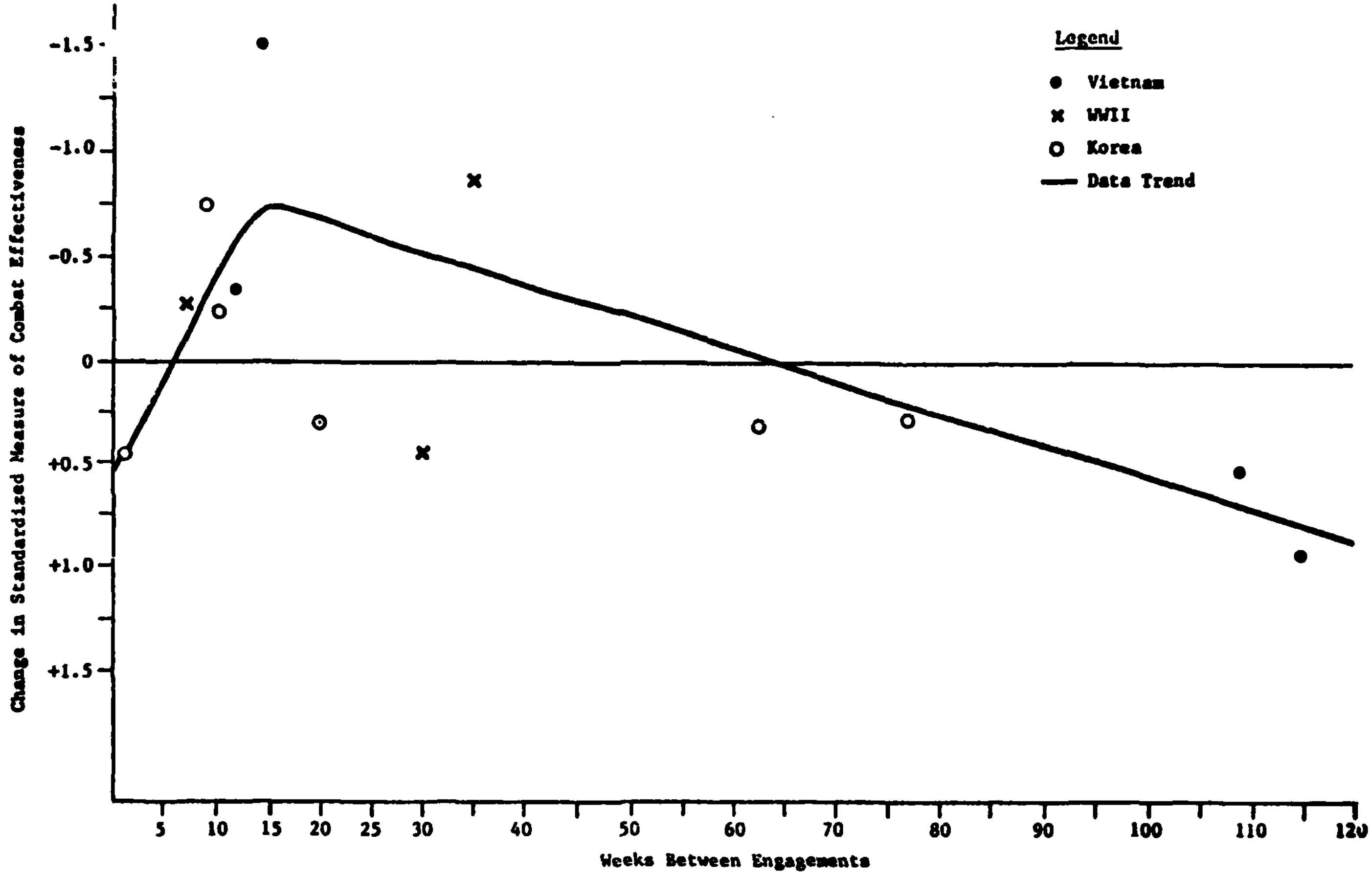
- Enhanced combat effectiveness decays after twelve weeks of separation between engagements and deteriorates rapidly thereafter.

- Whether due to personnel changes, exhaustion or loss of reactive capability, long periods of time between engagements are associated with falling combat effectiveness.

TABLE 2

Standardized Combat
Effectiveness Scores

ID#	Standardized Score	Change In Standardized Score
14	-0.1184	-0.2433
15	-0.3617	
23	0.5038	-0.8655
24	-0.3617	0.4129
25	0.0512	
6	-0.107	-0.2165
20	-0.3235	
11	-0.5144	0.4072
18	-0.1072	
32	0.6565	0.2999
22	0.9564	
28	-0.1072	-0.7468
29	-0.8540	0.2973
30	-0.5567	0.2968
31	-0.2599	
35	0.3765	-0.2291
36	0.1474	0.922
37	1.0694	-1.5329
38	-0.4635	0.5854
39	0.1219	



Note: __Negative__ Z-score differences mean a __positive__ change in performance (because 1 = best, 10 = worst).

Figure 2. Plot of Standardized Data for Change in Combat Effectiveness

CHAPTER 13. SHOCK AND SURPRISE

INTRODUCTION

The nature of the battlefield of the future is almost impossible to predict with confidence. Each major conflict brings its technical innovations and tactical changes. World War I brought massive firepower to bear, forced entrenchment tactics, and ended the effectiveness of mass charges. World War II brought blitzkrieg and amphibious warfare from the realm of the theoretically possible into the technical and tactical real world. Korea demonstrated the importance of political variables and subjected U.S. fighting forces to extremes of weather and stress that are almost unimaginable. The Vietnam War retaught the lessons that tactics can defeat technology and reminded the military of the importance of political conditions in modern conflicts. The 1973 Middle East War showed the importance of effective counter-air resources on the armor intensive, open country battlefield.

With hindsight, all these changes and developments seem to make sense. To the soldier on the battlefield at the beginning f a conflict, however, they represent a sudden confrontation with the unexpected. Particularly in the first few days and hours when a new technology or tactic appears on the battlefield, the infantryman and his unit are subjected to severe shock and surprise. Their ability to react to the new development, or their inability to formulate an effective response, may well determine the survival of the unit or the outcome of a conflict. Hence, a specific effort was made during the Phase II research to examine the impact of shock and surprise on the battlefield and to learn how units that successfully deal with shock and surprise differ from those that are unable to cope with them. The goal of this effort was, therefore, to establish priorities for developing, equipping,

and training units that have a high probability of effective combat performance even when faced with shock and surprise on the battlefield.

THE IMPACT OF FRIENDLY SURPRISE

Some variables were collected that measure the impact of surprise by friendly forces across the basic set of 41 operations under study. For example, the officer coders participating in the judgmental analyses were asked to evaluate the use of the principle of "surprise" by friendly forces both in the planning phase of each engagement and in the operations themselves. The correlation between these variables and combat effectiveness is shown in Table 1.

TABLE 1

Correlation of Judgments About the Impact of Surprise by Friendly Forces With Combat Effectiveness

ID Number	Variable	r	n	r^2	s	Mean Importance
C30	Plan: Surprise	-.26	258	.07	.001	2.3
C70	Execution: Surprise	-.24	253	.06	.001	2.2

The Pearson product-moment correlation coefficients are relatively weak for both variables, although they were coded as influencing the outcome of the engagements by a relatively high percentage of the officer coders. Interestingly, the mean importance scores assigned to the two variables were among the lowest in the 60 judgmental variables rated. The percentages of variance explained were also quite small.

- While surprise by friendly troops showed a statistically positive association with the probability of effective combat performance, the percentage of variance explained is relatively small and officer coders indicated that friendly surprise has little influence on the overall engagement outcome.

A second analysis was undertaken in the historical data. This effort focused on the type of surprise by friendly unit. The breakdown of this variable with the combat effectiveness measure is shown in Table 2.

TABLE 2

Association of Type of Friendly Surprise With Combat Effectiveness

		Type of Surprise					
		None	Tactics	Strength	Location	Weapons	
Mean Outcome Score	1-2.79	5	8	4	0	1	18
	2.80+	8	7	1	1	2	19
		13	15	5	1	3	37

Too few cases per cell for meaningful statistical summarization.

In the absence of surprise of any type, the probability of effective combat performance is approximately .38. Given surprise, friendly forces have a probability of .54 of combat effectiveness. This difference is not large (would not even approach statistical significance for the number of cases involved) and is due almost entirely to the strong impact of surprise in strength.

- There is a small, statistically nonsignificant tendency for surprise by friendly forces to increase the probability of effective combat performance.
- Surprising friendly strength has a much stronger association with improved probability of effective combat than surprise in tactics, location or weapons. The number of cases in each category is too small, however, to support statistical analysis.

THE IMPACT OF ENEMY SURPRISE

Two different approaches were taken to evaluating enemy surprise and its impact on friendly combat effectiveness. The first involved historical analysis of the entire set of 41 engagements under study and the other focused on eight carefully chosen cases where United States Marine Corps battalions experienced severe shock and surprise.

The first analysis was a breakdown of the basic data set into types of enemy surprise by combat effectiveness of friendly forces. The results of that analysis are shown in Table 3.

TABLE 3

Association of Type of Enemy Surprise With Friendly Combat Effectiveness

	Type of Surprise: None	Tactics	Strength	Location	Weapons	
Mean Outcome Score 1-2.79	7	5	6	2	1	21
Mean Outcome Score 2.80+	6	8	3	3	0	20
	13	13	9	5	1	41

Too few cases per cell for meaningful statistical summarization.

The pattern is quite surprising. First, the relative probability of effective friendly performance, given enemy surprise is .50, versus a probability of .54 when no enemy surprise was present. This is virtually no difference at all. Second, surprising enemy strength is associated with a rather high percentage of combat effective performances by U.S. Marine Corps battalions. There is some tendency for enemy tactical

surprise to lower the probability of effective performance. Neither surprising location or weapons show any particular trend.

- Across the 41 engagements studied, there is no tendency for surprise by enemy forces to be associated with a change in the combat effectiveness of U.S. U.S. Marine Corps battalions.

- There is an apparent tendency for surprising enemy strength to be associated with a higher probability of effective combat performance by U.S. Marine Corps battalions. This tendency is not statistically significant.

- There is an apparent tendency for surprising enemy tactics to be associated with a lower probability of effective combat performance. Tactical surprise, rather than strength, location, or weapons, appears to be effective against U.S. Marine Corps battalions.

SPECIAL SHOCK AND SURPRISE ENGAGEMENTS

The general finding, that Marine Corps battalions were not greatly affected by enemy surprise, was one of the Phase I findings that generated interest in special analysis of the issues surrounding shock and surprise. One hypothesis offered as an explanation of the apparent good performance under adverse conditions was the possibility that mild surprises of the type frequently experienced on the battlefield were being coded as "surprise" but were not really severe enough to result in change from normal combat. To guard against this potential problem and to test the hypothesis, a special set of cases were especially selected in Phase II. These were situations where severe shock and surprise were clearly inflicted on friendly units by enemy forces. The cases chosen are listed in Table 4. Two were drawn from World War II, three from Korea and three from Vietnam. The types of surprise represented were largely enemy tactics and enemy strength, the two types shown to have the greatest potential impact.

TABLE 4

Shock and Surprise Engagements

ID#	Short Title	Unit	Combat Era	Mean Rank
26	Iwo Jima II	2/25	WWII	2.2
27	Tarawa	2/2	WWII	2.2
32	Sudong	1/7	Korea	4.3
33	Battle of NW Ridge	2/5	Korea	2.3
34	Yudam-ni	3/7	Korea	3.7
36	UTAH	2/7	RVN	3.3
40	TEXAS	3/7	RVN	3.4
41	BUFFALO	1/9	RVN	3.3

Of course, the cases were selected for inclusion in the research before their mean outcome could be known. As Table 1 shows, a wide range of outcomes was observed in the eight cases. Iwo Jima II, Tarawa, and the Battle of NW Ridge were rated as very combat effective actions. The Sudong and Yudam-ni were scored as quite poor performances. UTAH, TEXAS, and BUFFALO were ranked well below the mean (about 2.8) but within the central case cluster for the full set of 41. Clearly, there is an association with combat era -- the best two cases are World War II situations -- but that could not be prevented in the research design phase since the outcome scores were established by officer coders during the project.

A test was made to determine whether the eight shock and surprise cases, as a set, were statistically different in outcomes (mean or variance) from the rest of the cases considered. Table 5 reports these tests.

TABLE 5

Comparison of Combat Effectiveness Ratings in Shock and Surprise Engagements With All Other Engagements

	Number of Codings	Mean Rankings
Shock and Surprise Engagements	67	3.13
Other Engagements	240	2.89

T probability = .325

F Probability = .737

Sixty-seven officer codings were available on the eight shock and surprise engagements, 240 on the other engagements. While the mean ranking of the shock and surprise engagements was somewhat higher (indicating worse performance), the difference, as measured by a t-test was not

close to significance. The F test for differences of variance also showed nothing.

- Overall, the combat effectiveness of U.S. Marine Corps battalions experiencing severe shock and surprise on the battlefield is not different from the combat effectiveness of battalions that do not experience them.

COMPARING THE CRUCIAL DETERMINANTS OF COMBAT EFFECTIVENESS WITH AND WITHOUT SEVERE SHOCK AND SURPRISE

The fact that the outcomes or combat effectiveness rankings are not different when shock and surprise are severe is interesting, but does not mean anything with respect to the structure of the processes involved. One of the major research issues in shock and surprise is how the factors determining effective and noneffective combat performance differ (and whether they differ) when these factors are present. Unfortunately, the small size of the relevant base combined with the relatively subtle nature of the relationships identified between historical variables and combat effectiveness preclude meaningful analyses. On the other hand, the set of 67 officer codings on judgmental variables about the eight severe shock and surprise cases was large enough to permit a relatively thorough analysis.

The judgmental critical factors found to be meaningfully related to combat effectiveness during the analyses of the full set of 41 cases were, therefore, correlated with the eight cases of severe shock and surprise.

Critical Factors During Precontact Phases

Three sets of precontact variables were examined -- unit composition and training, planning, and preparatory fires. Table 6 shows the results of these analyses and provides comparative values for the set of "all engagements".

TABLE 6

Comparison of Judgmental
Critical Factors For Shock and Surprise
Engagements With All Engagements: Precontact Phases

			Correlation with Combat Effectiveness in Shock and Surprise Cases					Association with Combat Effectiveness in All Cases	
Category	ID#	Variable	r	n	s	r^2	Mean Importance	r	Mean Importance
Unit Composition and Training	C6	Training	-.37	55	.002	.14	2.7	.12	2.7
	C8	Morale (Prior)	-.16	35	.173	.03	2.7	.06	2.8
Planning	C10	Quality of Information	-.16	59	.106	.03	2.8	.04	2.8
	C12	Plan Quality	-.38	64	.001	.14	2.7	.13	2.7
	C14	Plan: Principles of war	-.50	55	.001	.25	2.6	.16	2.7
	C34	Timeliness of Orders	-.24	51	.048	.06	2.5	.10	2.5
	C36	Plan: Use of Reserves	-.38	55	.002	.14	2.7	.10	2.6
	C38	Plan: Logistics	-.21	41	.099	.04	2.8	.06	2.7
	C40	Plan: Subordinate Units	-.35	51	.009	.12	2.8	.22	2.8
	C42	Awareness of Enemy	-.29	64	.010	.08	2.8	.10	2.7
Preparatory Fires	C82	Preparatory Air Interdiction	.30	28	.06	.09	2.4	.00	2.5

The unit composition and training variables produce quite comparable results in severe shock and surprise engagements and in all engagements. Training is a statistically significant factor. The weak relationship shown between prior morale and combat effectiveness in all engagements is even weaker in severe shock and surprise cases.

Some differences can be observed between planning variables in severe shock engagements and the overall data set. The most dramatic is a sizable decrease in the importance of planning for the use of subordinate units (from $r^2 = .22$ to $r^2 = .12$), although the variable retains a significant explanatory power in the severe shock and surprise cases. A large increase in the importance of planning on the basis of the principles of war also occurs, probably suggesting that units experiencing strong surprise failed to do their planning on a completely sound basis. The importance of planning for proper use of reserves also shows an increase in the analysis of severe shock cases, but not a large one (from $r^2 = .10$ to $r^2 = .14$). Quality of plan remains a statistically significant factor at about the same level as in all engagements.

Variables showing decreases in explanatory power include, somewhat surprisingly, awareness of the enemy and his capability. While this is a small change, the natural expectation would be an increase. Timeliness of orders and logistics planning fall from marginally important in all engagements to probably irrelevant in shock and surprise cases, while quality of information remains quite small ($r^2 = .03$).

The one judgmental variable available on preparatory fires, interdiction, jumps from 0 percent of variance explained to 9 percent, but this is based on only 28 officer codings, involving only three of the eight engagements; is heavily influenced by the relative success of one of them; and is in the wrong direction. Hence, no valid logical or statistical generalization can be drawn from the information.

- Unit training is a significant factor in determining the combat effectiveness of units experiencing severe

TABLE 7

Comparison of Judgmental Critical
Factors For Shock and Surprise Engagements
With All Engagements: Battalion During the Operation

		Correlation with Combat Effectiveness in Shock and Surprise Cases					Association with Combat Effectiveness in All Cases	
ID#	Variable	r	n	s	r^2	Mean Importance	r	Mean Importance
C52	Overall execution	-.41	64	.001	.17	2.8	.27	2.9
C54	Implementation: Principles	-.38	45	.005	.15	2.7	.27	2.8
C74	Maneuver	-.41	63	.001	.17	2.8	.21	2.7
C76	Use of fire	-.21	50	.072	.04	2.9	.15	2.9
C90	Night positions	-.18	48	.111	.03	2.7	.09	2.6
C92	Position preparation	-.30	35	.042	.09	2.6	.09	2.6
C94	Security on the move	-.16	33	.180	.03	2.7	.19	2.7
C98	Linkages: External	-.03	53	.406	.00	2.8	.08	2.8
C100	Reaction to unexpected	-.29	66	.008	.09	2.8	.19	2.8
C102	Morale (during)	-.07	31	.349	.01	2.8	.04	2.8
C104	Discipline	-.32	37	.025	.10	2.9	.14	2.9
C106	Aggressiveness	-.31	62	.007	.10	2.9	.15	2.8
C108	Initiative	-.23	60	.036	.05	2.8	.16	2.8
C110	Resourcefulness	-.47	56	.001	.22	2.9	.22	2.8
C112	Casualties (impact)	-.18	57	.086	.03	2.7	.09	2.5
C128	Communications	-.16	40	.044	.03	2.8	.10	2.8

shock and surprise, but probably no more important in these cases than in other cases.

- Morale prior to combat is not associated with the probability of effective combat performance when the unit experiences severe shock and surprise.

- Planning variables are important determinants of combat effectiveness when severe shock and surprise occurs.

  - Planning for use of reserves is more important when shock and surprise are encountered than in their absence.

  - Specific plans for the use of subordinate units, except reserves, are less important when severe shock and surprise occur than when they are absent.

- Intelligence variables have little to do with effective combat performance when severe shock and surprise are encountered.

- Logistics planning is of marginal importance when severe shock and surprise are encountered.

Critical Factors During the Engagement

The largest set of actions relevant to effective combat performance when shock and surprise are experienced relate to the activities of the unit itself. Sixteen relevant variables were identified and their correlations with combat effectiveness are shown in Table 7. The most striking finding from this table is that virtually all the r^2 values (percentages of variance in the combat effectiveness measure associated with the critical factors) show large decreases when compared with the values for all engagements. This is even true of the "general" variables -- overall execution and implementation of the principles of war. A pessimist could read this clear pattern as an indication that there is very little that can be done to help a unit experiencing severe shock and surprise -- their fates are "in the hands of the gods," or, less philosophically, "randomly determined".

The one major exception is "resourcefulness" which retains its .22 value for r^2 and strong significance. If the interpretation of this variable as the key measure of adaptive behavior is accepted, the case for training and evaluating units for flexibility and learning in the field is greatly strengthened.

Maneuver retains considerable importance under severe shock and surprise, although some loss of explanatory power (from $r^2 = .21$ to $r^2 = .17$) is evidenced. Only two other variables retain association with as much as 10 percent of the variance -- aggressiveness and discipline, while they do experience some declines in explanatory power. These two are closely intercorrelated as was noted in earlier analyses and probably represent a single concept. Preparation of positions, which holds the same 9 percent of variance in shock and surprise cases as it does in all engagements is probably a recognition of the interaction of discipline (the energy to prepare positions well in combat must often be generated by the will of unit leaders) and resourcefulness.

Reaction to the unexpected, while showing some predictive power ($r^2 = .09$) suffers a severe drop (from $r^2 = .19$) in severe shock and surprise cases, as does "initiative" (from .16 to .05). These changes, particularly when compared with the smaller declines and larger remaining explanatory power of aggressiveness, discipline, and position preparation suggest that units under pressure from shock and surprise must struggle to execute the basic functions of combat as they know them rather than attempt radical new departures. Here, again, powerful psychological concepts can be invoked. Under stress, human beings react with "dominant responses." The strength of the training, planning, discipline, and aggressiveness variables all suggest that a commander whose unit is experiencing severe shock and surprise must keep his personnel doing familiar, basic combat activities. This, which may well be all they are capable of, can keep them an effective combat force.

Several variables decrease in association with combat effectiveness under conditions of severe shock and surprise, ultimately registering little association. The most surprising is use of fire (from $r^2 = .15$ to $r^2 = .04$). External linkages and communications show sizable losses of explanatory power, emphasizing the isolation of units experiencing shock and surprise and the need to rely on their own resources to accomplish military missions. Security on the move shows the largest drop (from $r^2 = .19$ to $r^2 = .03$), probably because most of the shock and surprise units were not very mobile and/or were badly exposed when they did move. The impact of casualties on unit performance and the importance of night positions each fall from $r^2 = .09$ to $r^2 = .03$, which makes them essentially irrelevant in shock and surprise cases.

- The ability of unit experiencing severe shock and surprise during combat to improve its chances of effective performance by actions during the engagement is less than the ability of units not experiencing these pressures.

- Resourcefulness, discipline, and aggressiveness, including careful preparation of positions, form a cluster of activities that, kept intact, increase the probability of effective performance during severe shock and surprise engagements. Execution of basic combat functions is the essential activity in these cases.

- Maneuver is an important factor influencing the probability of effective combat performance during severe shock and surprise engagements, although somewhat less important in these cases than in other engagements.

- Use of fire is not associated with combat effective performance in severe shock and surprise situations and is much less important in these cases than in other engagements.

- Communications factors are not associated with combat effective performance in severe shock and surprise cases, and are less important in these cases than in other engagements.

- Security on the move is not associated with the probability of effective combat performance in severe shock and surprise cases and is much less important in these cases than in other engagements.

- The impact of casualties on unit performance and the importance of night positions, both marginally relevant in the analyses of combat effectiveness in all cases, are not associated with the probability of combat effective performance in severe shock and surprise situations.

Critical Factors in Combat Support and the Combat Environment

Four different elements are reported in Table 8 -- supporting fires, enemy forces, combat support, and combat environment. Of the supporting fires variables only one, armor support, shows an association with combat effectiveness in severe shock and surprise engagements. Artillery and close air support, both marginally relevant to the larger set of engagements, decline to clear irrelevance in this analysis. Naval gunfire, relevant in only two shock and surprise engagements, shows no association. Armor support, also relevant in only two engagements and coded only 17 times, shows a strong, wrong direction correlation that achieves statistical significance. As with close air support, the finding of a strong, wrong way relationship is based entirely on one case with a clear outcome and, hence, cannot be used as a basis for any generalization about combat effectiveness.

The no relationship finding is repeated when the quality of enemy forces is considered as a judgmental variable. The two elements of combat support that had frequent enough codings for analysis in the larger data set and the role of weather round out the data set. None of these factors is associated with combat effectiveness in severe shock and surprise cases.

- Supporting fires are not associated with combat effective performance in severe shock and surprise situations. The unit must determine its own relative effectiveness.

TABLE 8

Comparison of Judgmental Critical
Factors For Shock and Surprise Engagements
With All Engagements: Support Variables and Environment

Category	ID#	Variable	Correlation with Combat Effectiveness in Shock and Surprise Cases					Association with Combat Effectiveness in All Cases	
			r	n	s	r^2	Mean Importance	r	Mean Importance
Supporting Fires	C78	Support artillery	.04	51	.384	.00	2.8	.06	2.8
	C80	Naval gunfire	.01	22	.480	.00	2.6	.03	2.5
	C84	Close air support	-.01	49	.479	.00	2.7	.09	2.7
	C96	Armor support	.45	17	.033	.21	2.4	.02	2.3
Enemy Forces	C50	Quality of enemy	-.06	60	.308	.00	2.8	.01	2.7
Combat Support	C114	Medical support	.02	38	.451	.00	2.7	.01	2.5
	C116	Ammunition supply	.18	32	.169	.03	2.7	.05	2.7
Combat Environment	C48	Weather	-.09	57	.256	.01	2.4	.01	2.4

- The quality of enemy forces is irrelevant to combat effective performance in severe shock and surprise engagements.

- Combat support factors are not associated with combat effective performance when severe shock and surprise occurs.

- Weather is unrelated to combat effectiveness when several shock and surprise occurs.

COMBAT EFFECTIVENESS UNDER CONDITIONS OF SEVERE SHOCK AND SURPRISE

The critical factors associated with combat effective performance under conditions of severe shock and surprise have been gathered together in Table 9. They provide an interesting profile of the unit capable of effective performance under trying conditions.

The most important elements are the cluster of attributes that the unit must demonstrate on the spot -- resourcefulness, maneuver, aggressiveness, discipline and reaction to the unexpected. A military unit that is well led, at all levels from battalion to squad emerges from this description. Moreover, the leadership must rely on the basic combat activities carried out by each element in detail. The absence of initiative, normally a correlate of this group, makes it clear that familiar patterns and activities must be utilized to deal with the surprising elements. Radical changes from familar activities may well stretch the already strained organization and people beyond the point of control and destroy the capability for effective execution.

The importance of training in determining the outcome of severe shock and surprise cases is somewhat surprising. This is, of course, an activity completely executed prior to the engagement. However, the creation of the discipline and leadership necessary to perform effectively under stress is clearly forged in training and the officer coders were apparently able to distinguish the quality of training that the units had received from the narratives provided.

TABLE 9

Integrated Ranking of Key Variables
in Shock and Surprise Engagements

ID#	Variable	r^2	n	Ranking
C110	Resourcefulness	.22	56	1
C74	Maneuver	.17	63	2
C6	Unit training	.14	55	4
C12	Plan: Quality	.14	64	4
C36	Plan: Use of Reserves	.14	55	4
C40	Plan: Subordinate Units	.12	51	6
C106	Aggressiveness	.10	62	7.5
C104	Discipline	.10	37	7.5
C100	Reaction to the unexpected	.09	66	9
C92	Position preparation	.09	35	10

The presence of three planning variables in the set of influential determinants of combat effectiveness under severe shock and surprise is also interesting. Overall plan quality and plan for use of subordinate units are important factors in determining the effectiveness of units in all engagements and show less power in severe shock and surprise cases. The increased importance of planning for the use of reserves (which includes provision of an adequate reserve force and location of reserves) makes intuitive sense when the increased likelihood of use under severe conditions is considered. Planning, another activity largely completed prior to the engagement, is a significant factor in the effectiveness of units in these severe stress cases, fitting well with the argument that radical new actions and activities are not likely to help as much as execution of familiar combat functions.

The inclusion of preparation of positions in the influential set was a marginal decision. It can be seen as an isolated element or as a part of effective planning and disciplined execution by a well organized unit under stress.

Equally important, if not more so, are the factors absent from the list of variables determining combat effectiveness in severe shock and surprise situations. The influential set includes:

- No supporting fires,
- No communications variables, and
- No combat support elements.

In essence, the unit experiencing severe shock and surprise is seen as isolated by the officer coders. However, the earlier finding that judgmental codings tend to emphasize the unit and commander while historical data tends to measure the impact of supporting fires and other external forces must be remembered when this evidence is examined.

Based on the available evidence, however, to have a high probability of effective performance the unit must:

- Have been well trained,
- Be operating on the basis of a sound plan, and
- Have the leadership and discipline to execute basic combat functions.

It would not seem too much to conclude that the old advice of football coaches to "concentrate on blocking and tackling" may be highly relevant based on these analyses.

CHAPTER 14. VALIDATION OF FINDINGS BY COMPARISON WITH 1973 MIDDLE EAST WAR

INTRODUCTION

The original research design called for inclusion of cases drawn from the 1973 Middle East War in the database. This was intended as a validation exercise. The 1973 war is the most recent modern intensive combat. It was fought with relatively new technology and the Arab forces employed Soviet doctrine. Since the main research design used history as a basis for identifying and projecting combat effectiveness in the current battlefield, the most recent evidence available was considered desirable. In addition, the ability to differentiate the 1973 war findings from earlier eras would help in adjusting the projections of combat effectiveness to changing battlefield technologies.

Unfortunately, it proved impossible to obtain the data necessary to include battalion level infantry cases in the data set. A number of factors were involved in this development:

- Foreign government cooperation was needed and the research period of performance coincided with delicate discussions with those governments, reducing the feasibility of requesting formal assistance.
- The level of detailed information required to support a case is considerable. Even where records might exist, cost of transportation, translation, and so forth appeared prohibitive.
- The detailed level of information required and the recentness of the conflict raised security issues for the foreign governments.

Hence, an alternative research strategy was adopted to help obtain at least an indirect validity check.

First, a literature search was launched covering the Library of Congress, the U.S. Army Library, the Defense Documentation Center, and the Foreign Science and Technology Center. Documents relating lessons learned and, more commonly, descriptions of hardware performance, were reviewed. Both classified and unclassified materials were examined. Second, visits were made and discussions of both sources and substance held with personnel at the Defense Intelligence Agency and the Foreign Science and Technology Center. Third, a visiting Israeli officer who had commanded a battalion in combat during the 1973 war was asked to complete a set of coding forms for "typical" engagements in that conflict and later interviewed in depth on his experience.

This third technique proved by far the most productive as the literature, documentation, and work to date examining the 1973 Middle East War seems to be heavily concentrated on (a) hardware evaluations and (b) strategy. Work at the fighting unit level is almost nonexistent. This gap in analysis should be filled, and its closure grows more difficult as time passes, evidence is lost, and memories fade. The analysis in this chapter is judgmental and based on scattered evidence and reporting, but it does provide an effective cross-check to the empirical analyses.

THE 1973 MIDDLE EAST WAR: MAJOR FORCES PRESENT

Enough time has passed to put into context some of the exaggerated claims about revolutionary new warfare technologies in the 1973 war. Some new factors emerged, but it is certainly not clear that they are as important in the history of warfare as the machine gun, armor, or blitzkrieg doctrine. The major factors present in 1973 are a mixture of new elements with features often seen before. They appear to include, seen from a "friendly" Israeli side (this viewpoint is chosen because it approximates U.S. force viewpoints, and only for that reason):

- Enemy forces have relatively effective antiair capability. It is mobile, and located in frontal zones.

- Enemy air capability is a serious threat on the battlefield.

- Both sides know the terrain and are operating from pre-established plans and contingency plans during the first days of combat.

- Much of the battlefield is armor intensive.

- Enemy forces utilize Soviet tactics emphasizing breakthroughs at key points by utilizing mechanized forces.

- Enemy forces are artillery intensive, but these artillery pieces are towed, reducing their mobility when compared with friendly artillery.

- Enemy tactics are designed to compensate for the strength of friendly force structures.

- Enemy command and control mechanisms are relatively cumbersome and suffer loss of effectiveness after the first preplanned activities.

- Enemy achieves early surprise and has a shock effect on some friendly forces.

- Until completion of the enemy's preplanned surprise phases, the battlefield changes rapidly for friendly commanders, later this situation is largely reversed.

- Once combat is initiated, concealed movement is extremely difficult in the armor intensive areas.

- Friendly forces are moving into the battle area throughout the fighting; enemy forces are largely in place shortly after the conflict begins.

Most of these characteristics are appropriate for a test of the combat environment in Europe, but certainly not all of them. For example, concealed movement in Europe will be possible except when technologically sophisticated sensors are available to the enemy. Moreover, artillery mobility would be much greater for Soviet forces than it ever was for Arab forces. Enemy air forces would certainly be more numerous in the battle area, and the effectiveness of Soviet command and control is really not known today, but it should be expected to be better than that of the Arab forces.

Of equal or perhaps greater importance, are some elements of European warfare that are simply irrelevant in the Middle East. Soviet military leadership will certainly be distinctly different, at all levels, than Arab. United States and NATO forces would be operating in a complex political context. More modern antitank weapons would be available. Of course, the threat of nuclear weapons would also be present, as well as chemical and biological warfare capabilities for the enemy forces. In short, the 1973 war is not a perfect basis for comparison with the intensive battlefield expected in Europe, but there are a number of major similarities that make the analysis worthwhile.

The 1973 War Lessons

The veteran Israeli battalion commander provided the research team with a set of factors that he felt provided the edge in combat effectiveness. Briefly summarized, and in descending order of importance these were:

- Commanders win wars,
- Using smaller units (500 man battalions) provides more units to accept missions, more commanders to execute them,
- Commanders train from the squad up,
- 3:1 ratio in local advantage is sought,
- Local advantage is usually achieved by maneuver,
- Israeli forces in 1973 were largely inexperienced, except at repulsing border raids. This lack was overcome because they were very highly motivated, and
- Artillery, because it is more reliably available, is to be preferred over close air support.

This doctrine listing is probably somewhat constrained by judgment. It is, however, remarkably similar to the factors identified empirically in Chapter 11. Table 1 displays this information comparatively. The tops

TABLE 1

Comparison of Israeli Doctrine[a] and Lessons Learned from 1973 Middle East War With Combat Effectiveness Predictors

Israeli List		Combat Effectiveness Predictors	
1	Commander -- undefined	1	Command -- adaptive behavior
2	Command -- structure for adaptive behavior	2	Command -- leadership
3	Command -- leadership	3	Local advantage
4	Local advantage	4	Preparatory fires
5	Troop motivation	5	Planning
6	Reliable fire support (artillery)	6	Popular support
7	Close air support	7	Tactical execution
8	Unit experience relatively unimportant	8	Unit cohesion
		9	Intelligence
		10	Troop commitment
		11	Communications
		12	Logistics
		13	Modern battlefield

[a] Nothing in this discussion relates to official Israeli government doctrine or positions.

of the two lists are remarkably similar, particularly if the organizational argument of creating more units to accomplish more missions is recognized as a device for increasing adaptive behavior.

A SPECIFIC ENGAGEMENT

In addition to this general, or "doctrine" list, the Israeli officer was interviewed about his specific experience in combat during 1973. Discussion focused on the problems that had increased the difficulty of his command. Mention was made of these specific items:

- Unit cohesion and aggressiveness during shock and surprise,
- Communications (equipment and technical problems),
- Enemy artillery fire,
- Location of enemy forces, firing especially at night,
- Observation of the battlefield, generally
- Inappropriate unit training, and
- Ammunition shortage (illuminating shell).

A specific comment was made that enemy air forces were relatively rare in his sector and were not a serious threat to his troops when they did appear. Their appearance in a close air support role was effectively random -- they were not part of coordinated attacks involving enemy ground forces.

From the positive side, the availability of armored personnel carriers was a major factor in reducing casualties from enemy artillery. In addition, the existence of a fire support coordination center down at the platoon level proved to be very useful when engaging enemy forces in well prepared positions. Finally, artillery forces proved to be important in

stopping armored breakthroughs by standing their ground and using direct fire from prepared positions.

A distillation of this discussion, which, like the judgmental coding forms, was constrained by reference to a particular engagement, suggested several new insights:

- Battlefield information was a problem despite the generally good observation available.
- Unit cohesion and aggressiveness in shock and surprise were validated by his experience.
- Enemy artillery was the salient threat at battalion level, not air or antiair.
- Communications failures due to local conditions were a problem.
- The actions of the battalion centered on the creation of local superiorities -- by fire and maneuver.

SUMMARY

The other material developed on the 1973 war was highly consistent with this interview except that communication problems were not generally reported. The interesting results, besides the confirmation of the general list of important factors, were:

- The increased awareness of the need for battlefield intelligence,
- The salience of enemy artillery threat, and
- The ability of artillery forces to blunt armor breakthroughs when necessary.

With these exceptions, the 1973 Middle East War data largely validated the empirical research performed.

CHAPTER 15. IMPLICATIONS OF THE RESEARCH FOR FIELD EXERCISES AND THEIR EVALUATION

INTRODUCTION

One of the objectives of the research project was the improvement of field exercises and their evaluation so as to link combat effectiveness to combat readiness. During Phase I of the project, a review of the existing literature on evaluation was completed, a survey of field exercise evaluation systems was carried out, the research team became familiar with the Marine Corps Combat Readiness Evaluation System (MCCRES), and a visit was made by the project leader to Twenty-Nine Palms to observe the live fire exercises there (CACI, 1977).

Since then, an automated version of MCCRES (Marine Corps Combat Readiness Evaluation System Software Application, or MCCRESSA) has been developed under sponsorship of the Cybernetics Technology Office of the Defense Advanced Research Projects Agency (DARPA/CTO) and is now being placed in the field for use. In addition, the project leader was able to visit Camp Lejune and observe, firsthand, a battalion predeployment unit exercise all the way from planning phases through the execution of a simulated landing and mission. On the same visit, the Tactical Warfare Simulation Evaluation Analysis System (TWSEAS) was observed in use in the field. During coding exercises at Quantico, visits were arranged to view command post exercises involving officer students in the Command and Staff Course.

Based on this information, the experience of the research team, the research reported earlier, and discussions with a number of interested Marine Corps officers during the research execution, there appear to be three areas where this work can be utilized in improving field exercises and exercise evaluation.

1. Change the scenarios utilized in field exercises,

2. Change the MCCRES and MCCRESSA systems to incorporate historically derived factors for weighting, and

3. Collect new and different types of information.

CHANGES IN EXERCISE SCENARIOS

The use of field exercises, or any other type of performance test, is to a certain extent, a way of forcing students to study what the teacher wants them to know. The classic story of the history professor who always used the same list of 100 questions on his final examination because he only wanted the students to know those 100 things to pass is not very different from the use of MCCRES to establish unit goals and training priorities. In preparing for a field exercise, commanders can see the factors to be emphasized and train toward them. Successful training should lead to successful exercises which, in turn, indicate the desired readiness level. Accordingly, manipulation of exercise scenarios is a useful and well recognized way of influencing unit training emphases and capabilities.

A review of the research results suggests several areas that appear to be largely ignored today but can be expected to be important determinants of combat effectiveness in the battlefield of the future. Scenarios that cause the unit to exercise these functions include:

- Represent strong, effective enemy artillery capability and ensure that units take full protective measures (field fortifications) necessary to survive them.

- Assign missions that stretch the unit's own capabilities to generate local superiority, and that require such superiority for mission accomplishment. In this way, induce planning for use of support fires.

- Provide for enemy tactical surprise, particularly by using tactics that are unexpected such as chemical warfare, ambushes utilizing hidden armor forces, or attacks from unusual locations.

- Test unit discipline by providing stressful scenarios with strong restrictions on weapons utilization, movement, and so forth.

- Provide some false battlefield information both initially and during the engagement so that the problem of battlefield observation is emphasized.

- Utilize scenarios that require extensive friendly fire coordination so as to enhance capability to achieve local superiority.

- Jam communications with higher headquarters while providing a new threat to the unit itself to test for flexibility, initiative, and resourcefulness.

- Whenever possible, units should be placed on unfamiliar terrain.

Besides stressing the threats that have been found effective in earlier analyses, these suggested scenario emphases introduce situations in which the units must engage in adaptive behavior while not abandoning basic combat functions. The interaction of these two issues appears to be the key to combat effectiveness, particularly under shock and surprise. Field exercises must present problems that force effective training in these key areas.

INCORPORATION OF EMPIRICAL RESEARCH FINDINGS IN THE MCCRES AND MCCRESSA SYSTEMS

With the adoption of formal MCCRES reporting in July of 1978 and the increasing use of both MCCRES and MCCRESSA (where available) for informal training, the validity and reliability of these systems has become extremely important. Currently, the structure and weighting systems for each of the MCCRES volumes is based on human judgment -- usually one or two officers work -- critiqued and revised based on field comments, experience in exercises, and feedback from evaluators and evaluated units.

The database assembled for the CACI research project on combat effectiveness provides a unique opportunity to check the structure of the relevant

portions of MCCRES and validate the weighting systems relevant to infantry battalions and their immediate support.

Evaluation of the MCCRES structure would involve an examination of the functions that MCCRES incorporates and their comparison with the sets of functions found to be determinants of combat effectiveness. Undoubtedly there are some areas currently being stressed for which there is no evidence of leverage on the probability of combat effectiveness. More importantly, however, there may well be elements in the historical and judgmental data that show considerable association with combat effectiveness but are not being examined in the MCCRES system or are only partially examined.

Validation of the weighting system would be another valuable analysis. Human judgments tend not only to be biased but also to react to doctrine and recent learning. Comparison of the judgmental weights assigned by the MCCRES staff with those derived both for the 41 cases and the almost 400 officer codings that were carried out would identify areas where values should be examined more closely and/or changed.

The empirical data would provide assistance in two ways. First, incorporation of empirical findings provides a much stronger chance of emphasizing the basic functions and activities that determine combat effectiveness. Second, the use of systematic research in conjunction with the existing system will greatly enhance the credibility of the system as an evaluation tool and as a basis for discussions with Department of Defense and Congressional decision-makers.

COLLECTION OF NEW TYPES OF INFORMATION

The empirical research very clearly underscores the need to collect new types of information from field exercises. At a general level, the need is to collect information about the unit's ability to engage in adaptive

behavior. Acquisition of information about the operating environment, processing that information properly to develop a clear picture of what is going on, formulating options, choosing among them, issuing orders, and executing them are not enough unless the unit is capable of dealing with a changing environment.

- The unit will encounter some unexpected elements in any situation,
- Enemy behavior will change (adapt) over time, and
- Failure to adapt will render the unit vulnerable as enemy forces concentrate on known patterns of activity.

Data relevant to adaptive behavior are not difficult to collect, but the collection must be done systematically. Figure 1, for example, shows a hypothetical learning curve for a good unit on the Twenty-Nine Palms live fire exercise. All the data necessary for maintenace of this table pass through the hands of the exercise controllers. By observing the adaptive behavior of the unit, senior commanders will have a better knowledge of their effectiveness in combat. Similar learning data can and should be collected for the:

- Time it takes for major pieces of battlefield information to move from the line companies to the battalion commander or S-3.
- Time required for formulating an order when the unit leaders are faced with a new situation.
- Time necessary to detect and adapt to jamming or deception in communication channels.
- Time necessary to occupy a night position, and so forth.
- Speed of response to enemy air threat.

Stressing the learning and adaptive aspects of field exercises does not mean abandoning evaluation of levels of performance. These must also be

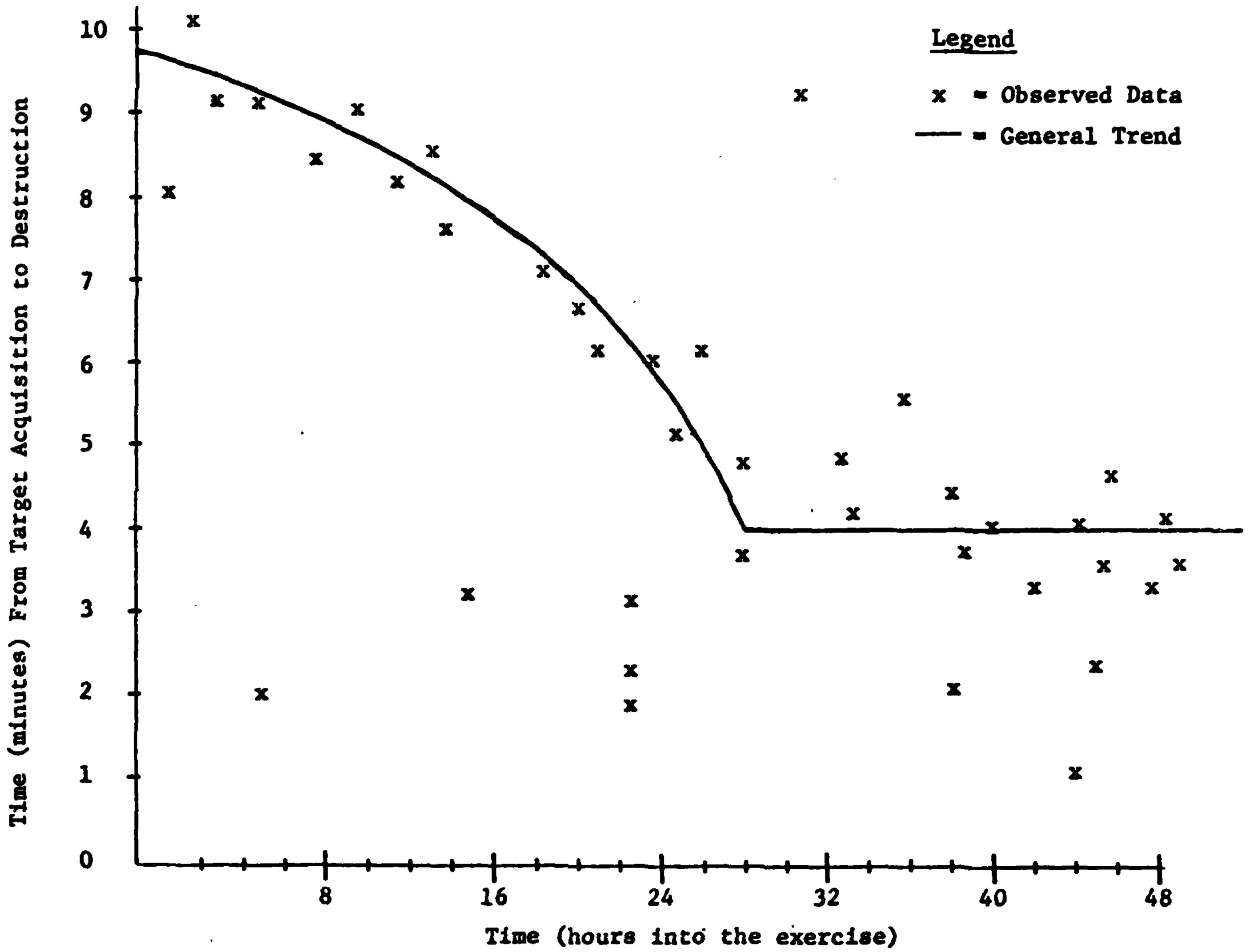


Figure 1. Adaptive Learning Behavior -- Engagement of Targets

evaluated, both because they provide a context within which learning is measured (a slow unit may show great improvement but never perform adequately) but also because of the clear finding that "blocking and tackling," the effective execution of routine combat functions, are an important aspect of unit command and correlate effective combat performance.

A second major area where new data should be systematically collected is in the unobtrusive measurement of actions by members of the unit that reflect the extent of individual discipline. These measures must be unobtrusive so that they can be "staged" only by a unit that has mastered its individual control problem. Among the available measures are:

- Average distance between individuals at mealtime.
- Average distance between individuals on the march.
- Average distance to flank guards on the march.
- Number of noise violations per company per night.
- Number of light violations per company per night.
- Number of personnel with physical fitness deficiencies.
- Number of individuals not wearing helmets during breaks.
- Number of individuals not carrying special equipment (especially chemical warfare or other seldom utilized equipment).

The important difference between these items and current procedures is the use of systematic collection and aggregation of records over time to determine "normal" rates and standards for acceptance.

Collection of these data will allow projection of unit discipline and cohesion factors that, while now understood to be important, are evaluated in a nonsystematic and noncomparable basis from exercise to exercise.

CHAPTER 16. FUTURE RESEARCH AND APPLICATIONS

INTRODUCTION

This research project is part of both a larger program sponsored by the Cybernetics Technology Office of the Defense Advanced Research Projects Agency (DARPA/CTO) and a growing literature on combat effectiveness. The project has already made relatively substantial contributions in both arenas.

- The definition of combat effectiveness as separate and studyable apart from combat readiness has identified a major need and opportunity for research.
- The development of a valid, replicable, and reliable way to measure combat effectiveness has provided a "dependent variable" for its study.
- The data set assembled in the project is unique in size, depth, and usage of both historical and judgmental variables to ensure coverage of all crucial elements influencing combat effectiveness.
- The methodology of combining history and judgment is unique and holds great promise for the study of combat effectiveness in other arenas.
- The analyses reported in this volume interrelate over 300 variables and identify their relative importance in influencing combat effective performance.
- The development of new approaches to field exercise design and evaluation that can be expected to result in making combat ready infantry units more combat effective.

However, the utility of the effort has only begun to be felt. This chapter discusses the related research activities and applications that can and should be undertaken in the near future. These include:

- Detailed analysis of the activities of battalion commanders and other key officers,

- Construction and sensitivity testing of a simulation model,
- Validation and improvements in the MCCRES and MCCRESSA systems,
- Evaluation of environmental factors influencing exercise results,
- Review of foreign and historical evaluation systems,
- Application of the research methodology in arenas other than infantry, and
- Design of an empirical budget impact system.

DETAILED ANALYSES OF COMMAND ACTIVITIES

The pervasive role of the battalion commander and the leadership functions in the analysis makes it very clear that a much better and more detailed understanding of the role and functions of individual leaders in combat and in making units ready for combat must be undertaken. Basically, the empirical evidence suggests that the single most important factor influencing the probability of combat effective performance is composed of a set of complex human functions.

- Resourcefulness,
- Initiative,
- Discipline,
- Aggressiveness, and
- Reaction to the unexpected.

While psychological studies of ways to identify these traits abound, very little has been done to teach them. A two pronged research effort is needed.

1. Identify in greater detail what a tactical unit leader does and how that is connected to the activities of the unit, and

2. Develop methods and tools for teaching the required skills.

CONSTRUCTION OF A SIMULATION MODEL

As a result of FY77 and 78 research, there is a sizable database available based on Marine Corps infantry battalions in 41 separate combat actions ranging from World War II through the Vietnam War. From this data base, multivariate techniques such as multiple regression and factor analysis have been used to explore the dimensionality and relative weights of over 300 factors influencing the ability of units to accomplish military missions. Basically, these data can be divided into four classes of information:

- Factors that can be determined prior to placing the unit in a hostile environment (unit composition, equipment types, experience of key personnel, and so forth).
- Functions that a unit must perform during combat, which also correspond to types and amounts of training or performance tests for specific functions (maneuver, planning, fire control, and so forth).
- Conditions beyond the immediate control of the unit (availability of artillery, air support, ammunition, and so forth) but within the general control of supporting forces.
- A combat environment consisting of exogenous variables that must be considered (enemy strength and capabilities, constraints on friendly actions imposed as a result of policy considerations, weather, mission assigned, and so forth).

The technical work in this effort is to take the very large number of individual attributes, functions, and factors that have been shown to have some impact on the results of combat engagements and integrate them with a simulation model. The construction of a simulation model based on

empirical parameters defined by regression analysis is not technically difficult. However, this model will initially suffer from severe problems of multicolinearity and insufficiency of degrees of freedom to support the very large number of factors that must be considered. An experienced simulation team can handle these problems by using "marker variables" for natural clusters and default values for a variety of factors that are not relevant to the analytical problems. However, it will require several months to construct, test, and validate the model.

The overall structure of the simulation model is shown in Figure 1. The user preprocessor is a program designed for use by either naive or sophisticated users. It will present questions to guide them through the available variables for describing a battalion in combat. Users may choose to select specific values for any of the descriptors in any of the four major files. Default values will have been precalculated for those factors that users do not wish to vary. Where appropriate, linkages between input values will be mapped. For example, outstanding fire coordination will be denegated if sufficient artillery ammunition is not available; enemy in prepared positions will be more difficult to attack than enemy in a hasty defensive posture.

Once the user has specified the unit to be examined by describing its attributes, relative skill with combat functions, available support, and combat environment, the precalculated paramaters for the unit will be drawn from the appropriate data files and moved to an integrated analysis module. This module calculates the relative effectiveness of the unit described under the conditions specified and reports these scores along with an analysis of the key functions contributing to the deviation from a "normal" unit. To facilitate exercise of the model, users may save the results of an analysis and/or calculate comparison statistics for use with specific previous runs or runs involving the default parameters for all variables.

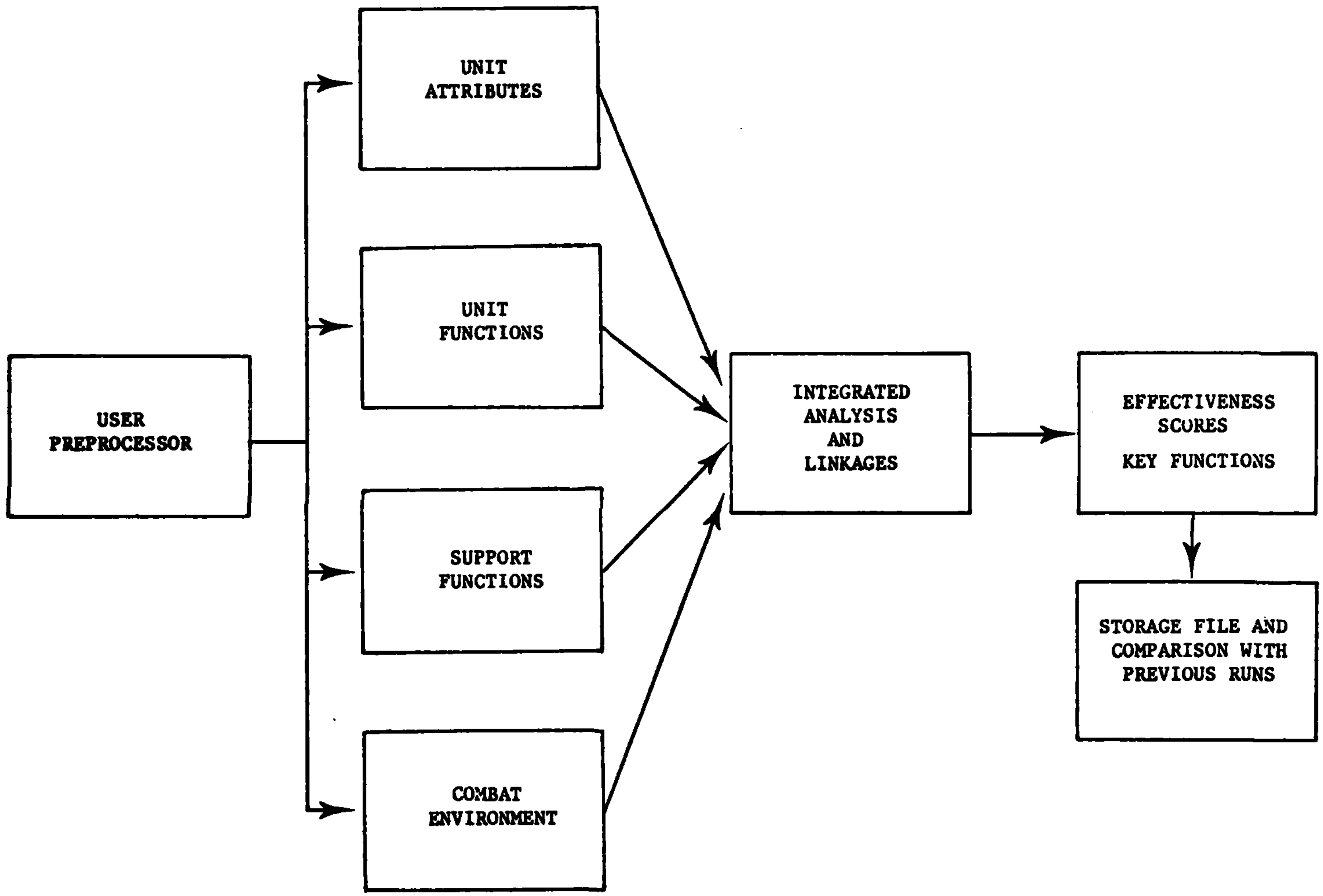


Figure 1. Simulation Model Structure

Sensitivity Analyses

Mere construction of the simulation model would serve little purpose. It must be exercised to establish its validity and produce new knowledge about interrelationships between the components of combat effectiveness and thresholds of performance. Hence, the research design should include about 4 months of work to produce a set of sensitivity analyses from the model and write a technical report that demonstrates its utility.

For instance, if users were interested in the implications of a decision to cut ammunition for training with artillery by 50 percent, they would then have to estimate the approximate impact of that cut on the capability of the unit to use artillery effectively. It would then be possible to calculate directly the difference between unit performance before and after the reduction of effectiveness in mortar usage. By altering the mission and/or enemy strength and capabilities, the impact of this change could be established under a variety of conditions. Several such analyses, chosen in consultation with representatives from the Marine Corps or U.S. Army, would produce a valuable report and document the potential of the simulation system.

VALIDATION AND IMPROVEMENT IN MCCRES AND MCCRESSA

The combat effectiveness simulation will facilitate a set of specific studies that map the results of the combat effectiveness research on the Marine Corps Combat Readiness Evaluation System (MCCRES). Many functions that are examined in the combat effectiveness research correspond to areas of interest in MCCRES. Currently, the MCCRES structure and the weighting system utilized to transform specific mission performance measures into overall scores are subjectively derived from the opinions of a few experienced officers, altered by feedback from the field.

The parameters from the combat effectiveness research can be used to validate and improve MCCRES in two specific ways:

1. Evaluate, validate, and, where indicated, revise the weights given to specific parts of MCCRES.

2. Develop recommendations for changing the MCCRES structure by deleting elements found to be of no importance, by adding new elements, or by reorganizing and integrating some areas.

The combat effectiveness results should not be used without careful thought and reflection. However, they do represent a very different, empirically based set of structures and weights that accurately reflect historical combat. Decisions to maintain structures or weights that directly contradict them should be deliberate and made because combat conditions have changed enough to justify them. Equally important, validated findings (the areas where MCCRES and the CACI combat effectiveness research are consistent) will greatly enhance the credibility of MCCRES and its value as a readiness indicator system.

EMPIRICAL EXAMINATION OF ENVIRONMENTAL FACTORS INFLUENCING EXERCISE OUTCOMES

In order to develop the capability to evaluate combat readiness based on exercise outcomes, it is necessary to examine a variety of factors that are neither collected at the time of exercises nor occur during their play. For example, the performance of a unit may be influenced by:

- Unit composition, particularly key personnel,
- Unit training emphases,
- Quality of life of the unit at its home base,
- The exercise environment (familiarization time, and so forth),

- Key personnel turbulence, and
- Support available for the exercise.

In addition, a variety of other pieces of information are useful because they allow comparison of exercise results with combat effectiveness data. These include:

- Data on the type(s) of mission assigned,
- Estimates of the relative costs of exercises, and
- Breadth of the functional areas tested.

The Marine Corps has begun keeping MCCRES scores, which are relatively comparable figures across exercises and can be tied directly to unit missions on all formal evaluations. This data set will grow rapidly and will make an excellent base point for empirical analysis to determine how exogenous factors are related to unit performances or exercises.

When this analysis is finished, two types of new information will be available:

1. The set of associations between exogenous variables and unit exercise performance, which can be used to evaluate the relative contribution of each exogenous factor and readiness.
2. A set of parameters that may be integrated with the combat effectiveness simulation to support budget impact analysis.

REVIEW OF FOREIGN AND HISTORICAL EVALUATION SYSTEMS

The research carried out thus far has focused largely on the U.S. Marine Corps, MCCRES, and its antecedents. In addition, both Marine Corps personnel and contractor personnel have examined the U.S. Army's Army Training Evaluation Program (ARTEP) system, which has a structure similar to

MCCRES but employs quite a different philosophy for application and reporting of results. There is a rich experience available from historical and current contexts, however, that has not been examined. Reviewing these historical and alternative current systems is more advantageous than observing our own systems -- we have either empirical evidence about their relative success or informed opinions about the quality of the forces they have produced. The research idea is to examine several specific historical systems to see what lessons can be learned from them and their applications. These include:

- The German system of exercise evaluation prior to World War II. This system apparently produced a well trained military organization that effectively utilized new weapons and tactics.

- The U.S. systems for evaluating unit exercises as they changed during World War II and the Korean war. Since these were adjusted to the realities of modern warfare, the areas of change should prove particularly illuminating.

- The system of exercise evaluation utilized by the Israeli military, which has also proven capable of producing effective units.

- The system utilized by the Soviet Union, particularly as it has changed over the past 10 years.

While these will be difficult subjects on which to obtain data, the results of the research effort may well prove extremely valuable in developing and designing new, improved systems for measuring combat readiness.

RECOMMENDATIONS FOR APPLYING THE READINESS METHODOLOGY OF COMBAT EFFECTIVENESS

The methodology developed by CACI under sponsorship of the Defense Advanced Research Projects Agency (DARPA) for measuring combat effectiveness and associating it with the factors that permit a military organization to succeed in a hostile environment is one of the very few

breakthroughs to have occurred in the field of evaluation since the end of World War II. The research methodology has been a subject of interest and appreciation in a variety of different organizations, including the Army, Navy, Air Force, and the Office of the Secretary of Defense.

To date, however, the methodology has been applied only to U.S. Marine Corps infantry battalions involved in ground warfare operations. CACI recommends that research be undertaken to determine the feasibility of performing parallel research or transferring the technology to perform this type of research in new functional areas or within the services. The approach is not universally applicable because it requires detailed information on either combat situations or exercises, as well as the availability of a number of experienced officers to act as judges for the judgmental sections of the data. On the other hand, the payoffs from the analyses are potentially tremendous. Research would have to be conducted on the availability of the resources necessary to complete the effort, and contacts would have to be made to ensure the effective cooperation of the organization that needed the results.

Properly carried out, this effort would result in opportunities for DARPA-sponsored research to impact on crucial areas for the Army, Air Force, and Navy, as well as the expansion of functional fields within the Marine Corps. Overarching functional areas, such as C^3, intelligence, and fire coordination, might also prove fertile grounds for the approach.

DEVELOP A DESIGN FOR AN EMPIRICAL BUDGET IMPACT SYSTEM

The culmination of the efforts would be the design of a computer system allowing simulation of specific budgetary actions and tracing their implications in the field of combat effectiveness/readiness. This system would include, as a central component, the Combat Effectiveness Simulator suggested earlier. A wide variety of other factors would, however, also be considered.

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The concept of combat effectiveness was defined as the ability of a military unit to accomplish its assigned mission in a hostile environment. Data were collected on 41 U.S. Marine Corps infantry battalion actions ranging from World War II through the Vietnam War. Over 200 historical (factual) variables were collected, including information about unit composition, training, engagement planning, preparatory fires, actions of the battalion during the engagement, supporting fires, combat support (logistics, communications, and medical) and

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the combat environment (enemy forces, terrain, weather, political conditions, and restrictions). The historical data were supplemented by judgmental information provided by 82 officer coders who indicated how well or badly the unit performed with regard to 60 specific factors affecting the unit. Their codings were based on reading narrative descriptions of the engagements that had been prepared by the research team. The officer coders ranged in rank from lieutenant to lieutenant-general (retired), in combat experience from World War II to Vietnam, in education from high school through master's degree, and included U.S. Army and Marine Corps officers who were attending or hand graduated from most of the senior schools in the military system. The bulk of the coders were Vietnam combat veterans and members of the Marine Corps.

The dependent variable -- combat effectiveness -- was measured by these same officers on a judgmental scale based on a six question survey instrument. Between 7 and 12 officers rated each engagement, based on random assignment. There proved to be very high agreement among the officers on the combat effectiveness ratings.

The data collected, including biographic information on officer coders to check for sources of bias, was subjected to a variety of bivariate and multibivariate statistical analysis procedures ranging from Chi-square and Pearson product-moment correlation to multiple regression, factor analysis, and discriminant function analysis.

The major findings of the study were (a) that the command function composed of adaptive behavior and leadership, were the strongest predictors of combat effectiveness, (b) that creation of local superiority through the use of maneuver, fire, and supporting fires is the key to effective performance, (c) that intense (24 hours or longer) preparations, effective intelligence and planning, and tactical execution also show positive association with combat effectiveness. Some political and policy conditions also correlate with effectiveness and control of the size of the logistics tail is essential for effective performance. Specialized analyses were also performed to learn how units change over time in combat and how they react under conditions of severe shock and surprise. Validating analyses were also conducted to relate the research findings to the lessons learned in the 1973 Middle East War.

A special section of the report is devoted to improving the conduct of field exercises. Recommendations are made for alteration of the scenarios utilized and for changes in the Marine Corps Combat Readiness Evaluation System (MCCRES) based on the research findings. Finally, collection of data related to (a) adaptive behavior and (b) unit cohesion and individual discipline, is recommended.

2 Volumes:

Technical Report
Technical Appendix